

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL TECHNICAL UNIVERSITY OF UKRAINE
“IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE”

HUMAN SAFETY AND CIVIL PROTECTION

PRACTICUM

Recommended by Igor Sikorsky KPI Academic Council as a tutorial for undergraduate students of specialties 121 “Software Engineering” and 123 “Computer Engineering”

Kyiv
Igor Sikorsky KPI
2021

Human Safety and Civil Protection: Practicum [Electronic resource] : the tutorial for undergraduate students of specialties 121 “Software Engineering” and 123 “Computer Engineering” / Igor Sikorsky Kyiv Polytechnic Institute ; Compiles: O. Ilchuk, V. Kalinchyk, Yu. Polukarov, A. Piatova, O. Polukarov. – Electronic text data (1 file: 0,65 b). – Kyiv : Igor Sikorsky Kyiv Polytechnic Institute, 2021. – 64 p.

*Approved by Igor Sikorsky KPI Methodological Council (protocol № 7 dated 13.05.2021)
after submission of Scientific Council of the Institute of Energy Saving and Energy
Management (protocol № 9 dated 26.02.2021)*

Electronic network educational edition

Human Safety and Civil Protection

PRACTICUM

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The tutorial is an instruction book for the implementation of 9 practices, which covers all sections of the discipline "Human Safety and Civil Protection". Each of the instructions contains the necessary theoretical information, tasks and progress steps, explanations for report preparation. The tutorial is designed to prepare undergraduate students of specialties 121 “Software Engineering” and 123 “Computer Engineering”.

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INTRODUCTION

By the decision of the Academic Council of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" to the cycle of basic training of bachelors of all engineering specialties of the university a new comprehensive discipline "Human Safety and Civil Protection" was introduced starting from the 2017/18 academic year. Its structure allocates 18 hours of practice for students in natural sciences, social sciences and humanities and information and communication technologies.

The purpose of practical classes is to deepen knowledge on specific topics, to develop skills and competencies to assess hazardous and harmful factors and possible consequences of their impact on human health, to evolve risk strategies to reduce the likelihood and minimize possible negative consequences of dangerous situations and emergencies, to provide first aid, to perform evacuation measures. During the practical classes an interactive environment is created. This will promote the development of students' creative thinking, form awareness of the need to solve in primary positions typical tasks of all areas of professional activity with mandatory compliance to occupational safety, responsibility for personal and collective safety in everyday life and during emergencies or during martial law.

The workshop consists of 9 instructions for practical works, which cover all sections of the discipline. Practical works are devoted to identify harmful and dangerous factors in the environment; quantitative risk assessment, their assessment for compliance with sanitary and hygienic norms and safety requirements; selection and operation of modern means of collective and individual protection; measures and means of fire safety; psychological aspects of security; rules about behavior and reaction in event of emergencies and emergencies, evacuation measures etc. Each of the instructions contains necessary theoretical information, tasks and progress steps, explanations for report preparation. Therefore the instruction can be used for distance learning.

TOPIC #1: PSYCHIC PROPERTIES OF PERSONALITY

Purpose of this work: to obtain the necessary practical skills on the methods of determining the types of human temperament by the basic properties of neuropsychic processes.

Statement

In this study we measure personality (using the Eysenck Personality Questionnaire) Eysenck found that their behavior could be represented by two dimensions: Introversion / Extroversion (E); Neuroticism / Stability (N). Eysenck called these second-order personality traits.

Each aspect of personality (extraversion, neuroticism and psychoticism) can be traced back to a different biological cause. Personality is dependent on the balance between excitation and inhibition process of the autonomic nervous system (ANS).

Task

To determine the type of temperament using the H. Eysenck test.

1. to answer all questions;
2. to calculate yeses an noes;
3. to determine your type of temperament.

Report

1. student's first name, family name, group and variant using *table 1.1*;
2. yes or no for each question;
3. type of temperament and conclusion.

For each question, the student answers only "Yes" or "No" using Table 1.1. Based on the results obtained, the student forms conclusions and makes recommendations for a specific type of temperament.

Extraversion

The sum of the "Yes" answers in the questions is calculated 1, 3, 8, 10, 13, 17, 22, 25, 27, 39, 44, 46, 49, 53, 56 and the answers are "No" in the questions 5,15, 20, 29, 32, 34, 37, 41, 51.

If the total score is 0-10, Then you are an introvert, immersed in yourself.

If you are 15-24, you are extroverted, sociable, and open to the outside world.

If 11-14, you are an ambivert, communicating when you need to.

Neuroticism

The number of "Yes" answers in questions is calculated 2, 4, 7, 9, 11, 14, 16, 19, 21, 23, 26, 28, 31, 33, 35, 38, 40, 43, 45, 47, 50, 52, 55, 57.

If the number of" Yes " answers is 0-10, this indicates emotional stability.

If 11-16, then this is an emotional vulnerability.

If 17-22, then there are some signs of looseness of the nervous system.

If 23-24, then neuroticism, bordering on pathology, is possible breakdown, neurosis.

Not true

The sum of points for the "Yes" answers in questions 6, 24, 36 and the "no" answers in questions is calculated 12,18, 30, 42, 48, 54.

If the score of 0-3 is the norm of human lies, the answers can be trusted.

If 4-5, then it is doubtful.

If 6-9, the answers are not reliable.

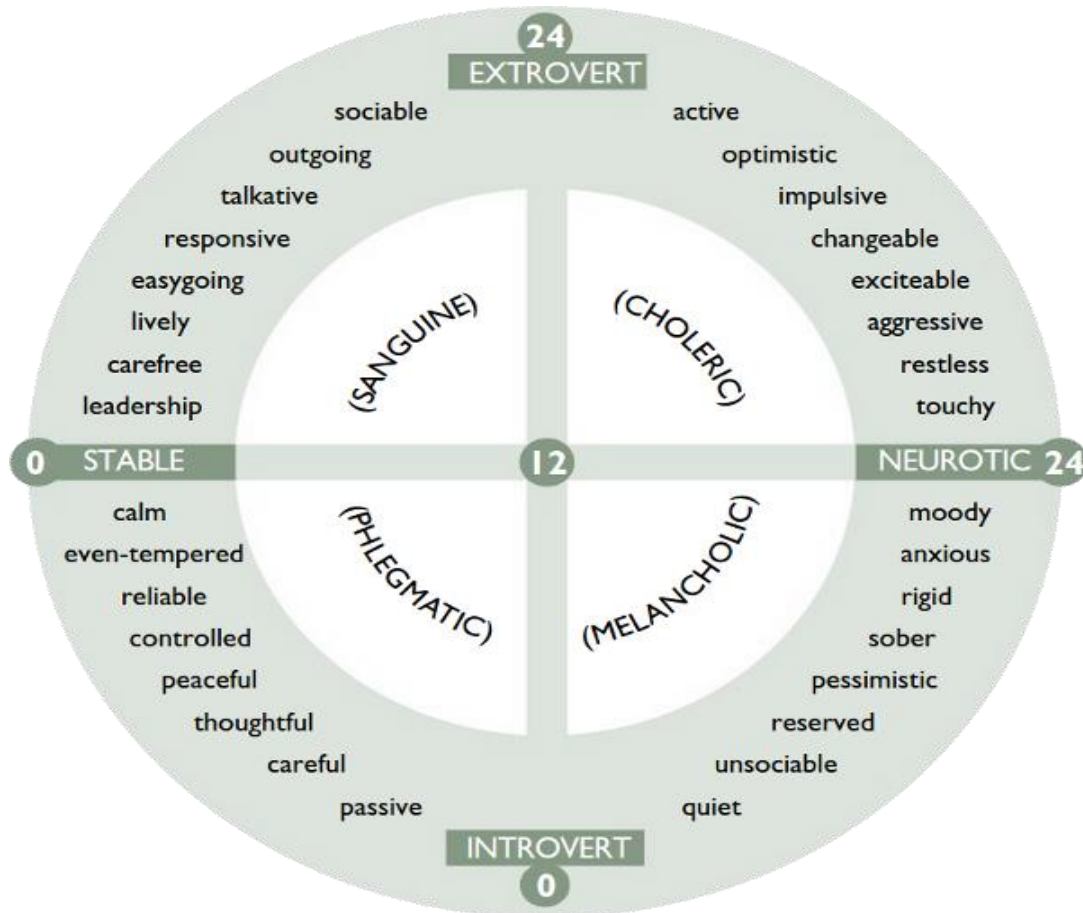


Fig. 1.1. Diagram for determining a person's temperament

Sanguine-extrovert: stable personality, social, directed to the outside world, sociable, sometimes chatty, carefree, cheerful, loves leadership, has many friends, cheerful.

Choleric-extrovert: unstable personality, excitable, unrestrained, aggressive, impulsive, optimistic, active, but performance and mood are unstable, cyclical. In a situation of stress-a tendency to hysteria psychopathic reactions.

Phlegmatic-introvert: stable personality, slow, calm, passive, unperturbed, cautious, thoughtful, peaceful, reserved, reliable, calm in relationships, able to withstand long-term adversity without disruptions of health and mood.

Melancholic-introvert: unstable personality, anxious, pessimistic, outwardly reserved, but at heart very emotional, sensitive, upset and worried, prone to anxiety, depression, sadness; in stressful situations, there may be a breakdown or deterioration of activity.

Type of nervous system (temperament)

Sanguine

Advantages: the joie de vivre, passion, compassion, sociability.

Disadvantages: a Tendency to arrogance, frivolity, number of floors, unreliability.

A nice sanguine person always promises not to offend another, but does not always fulfill the promise, so you need to check whether he has fulfilled his promise.

Phlegmatic

Advantages: firmness, constancy, patience, self-control, reliability

Disadvantages: slowness, indifference, dryness.

The main thing is that a phlegmatic person can not work with a lack of time, he needs an individual pace, so you do not need to adjust it, he will calculate his time and do the job.

Choleric

Advantages: energy, passion, passion, mobility, purposefulness.

Disadvantages: short temper, aggression, intemperance, impatience.

The choleric must always be busy, otherwise he will direct his activity at the collective and destroy it from within.

Melancholic

Advantages: high sensitivity, gentleness, humanity, benevolence, ability to empathize.

Disadvantages: low performance, suspiciousness, vulnerability, isolation, shyness.

The melancholic should not be shouted at, overly pressured, or given harsh and harsh instructions, because he is sensitive to intonation and very vulnerable.

Table 1.1

Student _____ Group _____ Variant _____

№	Question	Yes	No
1	Do you often long for excitement?		
2	Do you often need understanding friends to cheer you up?		
3	Are you usually carefree?		
4	Do you find it very hard to take no for an answer?		
5	Do you stop and think things over before doing anything?		
6	If you say you will do something do you always keep your promise, no matter how inconvenient it might be to do so?		
7	Do your moods go up and down?		
8	Do you generally do and say things quickly without stopping to think?		
9	Do you ever feel 'just miserable' for no good reason?		
10	Would you do almost anything for a dare?		
11	Do you suddenly feel shy when you want to talk to an attractive stranger?		
12	Once in a while do you lose your temper and get angry?		
13	Do you often do things on the spur of the moment?		
14	Do you often worry about things you should have done or said?		
15	Generally do you prefer reading to meeting people?		
16	Are your feelings rather easily hurt?		
17	Do you like going out a lot?		
18	Do you occasionally have thoughts and ideas that you would not like other people to know about?		
19	Are you sometimes bubbling over with energy and sometimes very sluggish?		
20	Do you prefer to have few but special friends?		
21	Do you daydream a lot?		
22	When people shout at you do you shout back?		
23	Are you often troubled about feelings of guilt? Are all your habits good and desirable ones?		
24	Are you often troubled about feelings of guilt?		
25	Can you usually let yourself go and enjoy yourself a lot at a lively party?		
26	Would you call yourself tense or 'highly strung'?		
27	Do other people think of you as being very lively?		
28	After you have done something important, do you come away feeling you could have done better?		
29	Are you mostly quiet when you are with other people?		
30	Do you sometimes gossip?		
31	Do ideas run through your head so that you cannot sleep?		

Table 1.1 (cont.)

32	If there is something you want to know about, would you rather look it up in a book than talk to someone about it?		
33	Do you get palpitations or thumping in your hear?		
34	Do you like the kind of work that you need to pay close attention to?		
35	Do you get attacks of shaking or trembling?		
36	Do you always tell the truth?		
37	Do you hate being with a crowd who play jokes on one another?		
38	Are you an irritable person?		
39	Do you like doing things in which you have to act quickly?		
40	Do you worry about awful things that might happen?		
41	Are you slow and unhurried in the way you move?		
42	Have you ever been late for an appointment or work?		
43	Do you have many nightmares?		
44	Do you like talking to people so much that you never miss a chance of talking to a stranger?		
45	Are you troubled by aches and pains?		
46	Would you be very unhappy if you could not see lots of people most of the time?		
47	47. Would you call yourself a nervous person?		
48	Of all the people you know, are there some whom you definitely do not like?		
49	Would you say that you were fairly self-confident?		
50	Are you easily hurt when people find fault with you or your work?		
51	Do you find it hard to really enjoy yourself at a lively party?		
52	Are you troubled by feelings of inferiority?		
53	Can you easily get some life into a dull party?		
54	Do you sometimes talk about things you know nothing about?		
55	Do you worry about your health?		
56	Do you like playing pranks on others?		
57	Do you suffer from sleeplessness?		

Conclusion:

TOPIC #2: QUANTITATIVE RISK ASSESSMENT

Purpose of this work: to obtain the necessary practical skills to use the existing detection algorithm.

Statement

Person with specific characteristics including its age, sex, place of residence, type of professional activity, lifestyle (main causes of additional risk). Additionally same thing for student itself.

Task

To calculate the risk of being exposed to a life-threatening hazard for yourself and for another person, according to the initial data, *table 2.9*.

1. to calculate the risk of death from somatic and genetic diseases, as well as through the natural aging of the body;
2. to calculate the risk of death during the year due to a possible industrial accident;
3. to calculate the risk of life-threatening death during the year as a result of a possible accident in the home;
4. to calculate the risk of being exposed to a life-threatening danger during the year due to its individual lifestyle;
5. to calculate total risk of being exposed to a life-threatening risk during the year;
6. to estimate the relative proportion of each risk of being exposed to a life-threatening hazard during the year is presented in the form of a pie chart, according to which overall conclusions are drawn;
7. to analyze of the absolute values of the components of the overall risk is carried out on an orderly scale of risks of lethal hazards.

Report

1. student's first name, family name, group and variant, using *table 2.8*;
2. risk of death from somatic and genetic diseases, as well as through the natural aging of the body: $R_1^* = \dots$;
3. risk of death during the year due to a possible industrial accident: $R_2^* = \dots$;
4. risk of life-threatening death during the year as a result of a possible accident in the home: $R_3^* = \dots$;
5. risk of being exposed to a life-threatening danger during the year due to its individual lifestyle: R_4^* and/or $R_4^{**} = \dots$;
6. calculate total risk;
7. estimate the relative proportion of each risk of being exposed to a life-threatening hazard during the year is presented in the form of a pie chart;
8. analyze absolute values of the components.

To calculate the risk of death from somatic and genetic diseases, as well as through the natural aging of the body use the formula:

$$R_1^* = K_{cfd} \cdot R_1, \quad (2.1)$$

where R_1 - risk for a person of a certain age group (*Table 2.1*);

K_{cfd} - correction factor for taking into account the place of residence of a person and his sex in diseases (*Table 2.2*)

Table 2.1

The risk of death of a person from genetic and somatic diseases and due to the natural aging of the body (for 1 person per year)

Age groups, by №	Age groups, years	Risk of death at home	Age groups, by №	Age groups, years	Risk of death at home
-	All groups together	0,01050			
-	Working age (15-60 years)	0,03800	№ 10	40-44	0,00270
№ 1	0	0,02300	№ 11	45-49	0,00480
№ 2	1-4	0,00080	№ 12	50-54	0,00840
№ 3	5-9	0,00030	№ 13	55-59	0,01500
№ 4	10-14	0,00020	№ 14	60-64	0,02500
№ 5	15-19	0,00030	№ 15	65-69	0,03800
№ 6	20-24	0,00040	№ 16	70-74	0,05900
№ 7	25-29	0,00050	№ 17	75-79	0,09100
№ 8	30-34	0,00090	№ 18	80-84	0,14300
№ 9	35-39	0,00160	№ 19	85 and older	0,24000

Table 2.2

Correction factor K_{cfd} depending on person's place of residence and sex

Type of settlement	Accidents		Diseases	
	Men	Women	Men	Women
City	1,6	0,28	1,45	0,38
Village	1,9	0,31	1,7	0,42

To calculate the risk of death during the year due to a possible industrial accident use the formula:

$$R_2^* = T_w \cdot R_2, \quad (2.2)$$

where R_2 - risk of life-threatening danger caused by various types of professional and non-professional activity (for 1 male person in 1 hour) (*Table 2.3*);

Note. If the value of R_2 in Table 2.3 has limits, then a smaller value must be selected.

T_w - number of working hours during the year - 2024 hours at 40 hours working week, and 1820 at 36 hours (teachers and students have 36 hours a week).

When examining the risk for the person of the opposite sex (women), the ratio of accidents caused by different activities between the persons of the opposite sex depending on their age is taken into account (*Table 2.4*) and the formula takes the following form:

$$R_2^* = T_w \cdot R_2 \frac{K_w}{K_m}, \quad (2.3)$$

Table 2.3

The risk of life-threatening injuries caused by various types of professional and non-professional activities (for 1 male person in 1 hour)

Activity code	Type of activity	Deadly risk	Activity code	Type of activity	Deadly risk
Production professions			15	Firefighters	$1 \cdot 10^{-7}$
1	Employees of carbonaceous enterprises	$5 \cdot 10^{-7} - 5 \cdot 10^{-6}$	16	Policemen, police officers, servicemen	$1,5 \cdot 10^{-7}$
2	Workers involved in the vulcanization process	$5 \cdot 10^{-7} - 5 \cdot 10^{-6}$	17	Professional drivers	$3 \cdot 10^{-7}$
3	Sailors on fishing trawlers	$6 \cdot 10^{-7}$	18	Professional Boxers	$4 \cdot 10^{-7}$
4	Workers of coal mines, miners	$2,5 \cdot 10^{-7} - 6 \cdot 10^{-7}$	19	Trackers, installers	$3,2 \cdot 10^{-6}$
5	Construction workers	$6 \cdot 10^{-7}$	20	Tractors	$4,2 \cdot 10^{-6}$
6	Potters and mockers	$2,5 \cdot 10^{-7}$	21	Pilots of civil aviation	$2,1 \cdot 10^{-7} - 1 \cdot 10^{-6}$
7	NPP workers (non-radiation risk)	$4 \cdot 10^{-8}$	22	Test pilots	$6 \cdot 10^{-5}$
8	Light industry workers	$5 \cdot 10^{-9} - 5 \cdot 10^{-8}$	23	Military helicopters	$1,2 \cdot 10^{-5}$
10	Heavy industry workers	$4 \cdot 10^{-8} - 6 \cdot 10^{-8}$	Non-professional sports, leisure		
11	Industry workers (as a whole)	$1,2 \cdot 10^{-7}$	24	Cyclists, skiers, track and field athletes	$3 \cdot 10^{-7}$
Non-manufacturing professions			25	Boxers, wrestlers	$4,5 \cdot 10^{-7}$
			26	Hunters, biathletes	$7 \cdot 10^{-7}$
12	Trade workers	$3,5 \cdot 10^{-8}$	29	Rowers, swimmers	$1 \cdot 10^{-5}$
13	Service workers, educators, students	$5 \cdot 10^{-8}$	30	Climbers, cavers, divers	$2,7 \cdot 10^{-5}$
			31	Jockeys, horsemen	$1 \cdot 10^{-4}$
14	Village workers, farmers	$6 \cdot 10^{-8}$	32	Car drivers	$1 \cdot 10^{-3} - 1 \cdot 10^{-5}$
			33	Other activities	$1 \cdot 10^{-8}$

Table 2.4

The ratio of accidents caused by different activities between persons of the opposite sex, depending on their age, %

Age groups, years	15-24	25-34	35-44	45-54	55-64	65-74
Men	80	81	76	74	71	62
Women	20	19	24	26	29	38
Total	100	100	100	100	100	100

To calculate the risk of life-threatening death during the year as a result of a possible accident in the home use the formula:

$$R_3^* = K_{cfa} \cdot R_3, \quad (2.4)$$

where R_3 - risk for a person of a certain age group (Table 2.5);

K_{cfa} - coefficient of correction to take into account the place of residence of the person and his / her sex in the case of accidents (Table 2.2).

Table 2.5

Risk of life-threatening fatal accidents for men of all ages (for 1 person per year)

Age groups, by №	Age groups, years	Risk of death at home	Age groups, by №	Age groups, years	Risk of death at home
-	All groups together	0,00092			
-	Working age (15-60 years)	0,00097	№ 10	40-44	0,00089
№ 1	0	0,00078	№ 11	45-49	0,00100
№ 2	1-4	0,00031	№ 12	50-54	0,00120
№ 3	5-9	0,00025	№ 13	55-59	0,00130
№ 4	10-14	0,00022	№ 14	60-64	0,00140
№ 5	15-19	0,00072	№ 15	65-69	0,00150
№ 6	20-24	0,00110	№ 16	70-74	0,00170
№ 7	25-29	0,00088	№ 17	75-79	0,00270
№ 8	30-34	0,00083	№ 18	80-84	0,00420
№ 9	35-39	0,00084	№ 19	85 and older	0,00700

To calculate the risk of being exposed to a life-threatening danger during the year due to its individual lifestyle use the formula:

$$R_4^* = K_{cfd} \cdot R_4', \quad (2.5)$$

where R_4' - risk of death of a person as a result of bad habits (Table 13.6);

$$R_4^{**} = K_{cfa} \cdot R_4'' \cdot T, \quad (2.6)$$

where R_4'' - risk of life-threatening danger caused by various types of professional and non-professional activity (for 1 male person in 1 hour) (Table 2.3);

Note. If the value of R_4'' in Table 2.3 has limits, then a smaller value must be selected

T – the amount of time a person spends on classes associated with additional risk factors.

Table 2.6

Risk of death of a person as a result of bad habits compared to the risk of non-productive deaths (per 1 person per year)

№	The source of the danger	The source of the danger	№	The source of the danger	The source of the danger
Bad habits					
1	Smoking	$8000 \cdot 10^{-6}$	2	Excessive alcohol consumption	$212 \cdot 10^{-6}$
Non-productive risks					
1	Random drownings	$91 \cdot 10^{-6}$	6	Occasional suffocation, obstruction of the respiratory tract	$58 \cdot 10^{-6}$
2	Road Accidents	$190 \cdot 10^{-6}$	7	Electric shock	$19 \cdot 10^{-6}$
3	Household poisoning	$97 \cdot 10^{-6}$	8	Suicide and self-harm	$258 \cdot 10^{-6}$
4	Random falls	$62 \cdot 10^{-6}$	9	Kills and willful damage	$117 \cdot 10^{-6}$
5	Fire damage	$48 \cdot 10^{-6}$	10	Effect of radon-222 contained in indoor air	$250 \cdot 10^{-6}$

Total risk of being exposed to a life-threatening risk during the year:

$$R = R_1^* + R_2^* + R_3^* + R_4^* + R_4^{**}, \quad (2.7)$$

An estimate of the relative proportion of each risk of being exposed to a life-threatening hazard during the year is presented in the form of a pie chart, according to which overall conclusions are drawn.

Qualitative analysis of the absolute values of the components of the overall risk is carried out on an orderly scale of risks of lethal hazards (table 2.7)

Table 2.7

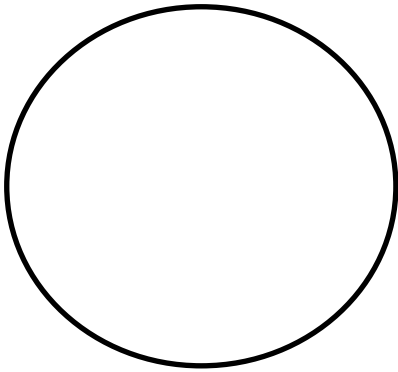
Occupational Safety Classifier

Security category	Conditions of professional activity	The risk of death of 1 person per year
1	Safe (sewing, shoe, textile, paper, typographic, food and forest industry)	$<0,0001$ ($R < 1 \cdot 10^{-4}$)
2	Relatively safe (metallurgical workers, Shipbuilding, coal mining industry, Cast iron, pottery and ceramic Productions, industry in general, and civil aviation workers)	$0,0001 \dots 0,0010$ ($1 \cdot 10^{-4} < R < 1 \cdot 10^{-3}$)
3	Dangerous (occupied by carbon dioxide and vulcanization Production, crew members of fishing trawlers, Construction workers, climbers, tractors)	$0,0010 \dots 0,0100$ ($1 \cdot 10^{-3} < R < 1 \cdot 10^{-2}$)
4	Particularly dangerous (test pilots, members Crews of military helicopters, divers)	$>0,0100$ ($R > 1 \cdot 10^{-2}$)

Student _____ Group _____ Variant _____

Task 1	Task 2
<p>Age –</p> <p>Gender –</p> <p>Residence – Kyiv</p> <p>Type of prof. activities – student</p> <p>Lifestyle (if there are major causes of additional risk):</p> <p>Bad Habits -</p> <p>active leisure (with hours per year) -</p> <p>1. $R_1^* = K_{cfd} \cdot R_1 =$</p> <p>2. $R_2^* = T_w \cdot R_2 =$</p> <p>or</p> $R_2^* = T_p \cdot R_2 \frac{K_w}{K_m} =$ <p>3. $R_3^* = K_{cfa} \cdot R_3 =$</p> <p>4. $R_4^* = K_{cfd} \cdot R_4' =$</p> $R_4^{**} = K_{cfa} \cdot R_4'' \cdot T =$ <p>5. $R_1^* + R_2^* + R_3^* + R_4^* + R_4^{**} =$</p>	<p>Age –</p> <p>Gender –</p> <p>Residence –</p> <p>Type of prof. activities –</p> <p>Lifestyle (if there are major causes of additional risk):</p> <p>1. $R_1^* = K_{cfd} \cdot R_1 =$</p> <p>2. $R_2^* = T_w \cdot R_2 =$</p> <p>or</p> $R_2^* = T_p \cdot R_2 \frac{K_w}{K_m} =$ <p>3. $R_3^* = K_{cfa} \cdot R_3 =$</p> <p>4. $R_4^* = K_{cfd} \cdot R_4' =$</p> $R_4^{**} = K_{cfa} \cdot R_4'' \cdot T =$ <p>5. $R_1^* + R_2^* + R_3^* + R_4^* + R_4^{**} =$</p>

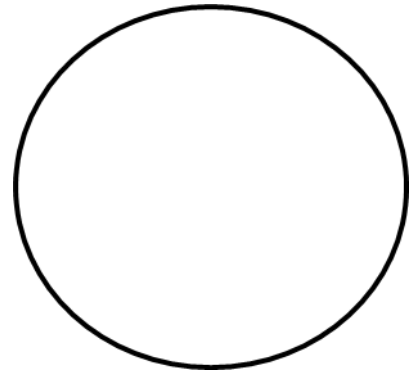
6. Diagram



7. Qualitative analysis of absolute values:

Conclusions:

6. Diagram



7. Qualitative analysis of absolute values:

Conclusions:

Table 2.9

INITIAL DATA

№ var.	Age, years	Sex	Locality	Type of professional activity	Activities related to additional risk factors
1	22	male	town	miner	smoking
2	25	male	village	farmer	excessive consumption of alcohol
3	29	female	town	teacher	Traveling by car, 150 hours a year
4	34	female	village	milkmaid	Cycling, 600 hours a year
5	45	male	town	builder	smoking
6	34	male	town	seaman of fishing trawler	Diving, 60 hours a year
7	58	male	village	driver professional	Hunting, 200 hours a year
8	40	male	town	civil aviation pilot, 1800 h per year	Rowing, 600 hours per year
9	45	male	village	artisan potter	Equestrian, 250 hours a year
10	22	female	town	light industry worker	Swimming, 250 hours a year
11	19	female	village	seller	Cycling, 500 hours a year
12	45	male	town	military helicopter 1600 hours per year	Boxing, 150 hours
13	51	male	town	NPP operator	smoking
14	38	male	village	cop	excessive consumption of alcohol
15	21	female	town	service worker	alpinism, 100 hours a year
16	50	male	town	miner	excessive consumption of alcohol
17	45	male	village	farmer	Traveling by car, 150 hours a year
18	30	female	town	teacher	Cycling, 600 hours a year
19	39	female	village	milkmaid	smoking
20	24	male	town	builder	Diving, 60 hours a year
21	26	male	town	seaman of fishing trawler	Hunting, 200 hours a year
22	25	male	village	driver professional	Rowing, 600 hours per year
23	45	male	town	civil aviation pilot, 1800 h per year	Equestrian, 250 hours a year
24	59	male	village	artisan potter	Swimming, 250 hours a year
25	34	female	town	light industry worker	Cycling, 500 hours a year
26	41	female	village	seller	Boxing, 150 hours
27	33	male	town	a military helicopter 1600 hours a year	smoking
28	57	male	village	NPP operator	excessive consumption of alcohol
29	40	male	town	Policemen	alpinism, 100 hours a year
30	40	female	village	service worker	smoking

TOPIC #3: AN ALGORITHM OF IDENTIFYING, ASSESSING AND REDUCING THE RISKS OCCURRENCE OF HAZARDOUS SITUATIONS

Purpose of this work: obtaining the necessary practical skills in usage of the existing algorithm of identifying, assessing and reducing the risks occurrence of hazardous situations at work.

Statement

In a production room with specific technological process (the technological process (operation) is selected by students independently, considering their professional direction of training), there is the risk of a hazardous situation.

Task

To evaluate the risks occurrence of hazardous situations at work.

1. to identify the main most hazardous and harmful production factors that can occur when performing a selected technological process (operation) to calculate depth, width and the area of chemical contamination;
2. to evaluate the possible baseline risks when this technological process (operation) applied;
3. to determine the residual risk assessment.

Report

1. student's first name, family name, group and variant using *table 3.5*;
2. the main most hazardous and harmful production factors that can occur when performing a selected technological process, sources of their occurrence, action, degree of risk, as well as the possible consequences of a negative impact on the subject at risk area;
3. residual risk assessment.

Identify the main most hazardous and harmful production factors that can occur when performing a selected technological process (operation), sources of their occurrence, action, degree of risk, as well as the possible consequences of a negative impact on the subject at risk and fill in the appropriate columns (1-5) in the Risk Assessment Map (table 3.4) for each of the most hazardous and harmful production factors identified (maximum three). In addition calculate a summary of those risk prevention measures that apply to the workplace.

The baseline risk degree of a dangerous situation is determined by the formula:

$$\mathbf{R} = \mathbf{S} \cdot \mathbf{P} \cdot \mathbf{H}_s, \quad (3.1)$$

where **R** – risk degree;

S – severity and possible consequences of hazardous event;

P – possibility of being hit by a hazard;

H_s – probability of a certain hazardous situation occurring.

The conditional probability of a dangerous event occurrence in numerical reproduction is determined by expert evaluation according to **Table 3.1**.

Table 3.1

Probability	Comments
5 – almost certainly	A regularly observed event. An event happens in most cases
4 – quite likely	A periodically observed event.
3 – likely	A sometimes happening event.
2 – unlikely	A rare event.
1 – almost impossible	An event only happens in exceptional circumstances.

Expert evaluation is carried out by a group of appointed experts.

The severity and possible consequences of a dangerous event in numerical reproduction are determined according to **Table 3.2**.

Table 3.2

The severity of a hazardous event		Possible consequences
5 – catastrophic	Group accident (2 or more workers injured); a fatal accident; emergency; fire.	Investigation by public authorities. Criminal liability. Ukrainian penalties. Stop of work. License revocation for an activity.
4 – essential	Severe accident (temporary disability for more than 60 days). Occupational diseases. Incident, fire.	Investigation by public authorities. Criminal liability. Ukrainian penalties. Possible stop of work.
3 – minor	Serious injury, illness with temporary disability for up to 60 days. Incident, fire.	Investigation by public authorities. Ukrainian penalties. Possible stop of work.
2 – minimal	Injury without disability, need for inpatient care, easier work. Incident, fire.	Internal investigation. Administrative responsibility. Penalties.
1 – irrelevant	Insignificant trauma (cut, stabbing), primary care provided.	Disciplinary responsibility.

The possibility of being hit by a hazard is determined according to **Table 3.3**.

Table 3.3

The numerical value	Characteristic
3	Permanent possibility of being hit by a hazard (daily)
2	Rare possibility of being hit by a hazard (once a month)
1	Minimal (once or several times a year)

Considering the results received in previous task, evaluate the possible baseline risks when this technological process applied. Put the results in the appropriate columns (7-10) of the Risk Assessment Card. If an unacceptable level of risk is obtained, propose appropriate precautionary measures.

If additional measures are needed to reduce the unacceptable level of risk, a residual risk assessment should also be carried out. To do this, it is necessary to determine whether the degree of risk of a dangerous situation has become acceptable, i.e. whether the implemented measures have the expected effect. Put the results in the appropriate columns (12-15) of the Risk Assessment Card.

To develop plan of measures, according to baseline risk assessment the comments in **Table 3.4** should be considered.

Table 3.4

Risk degree	Comments
Extreme (55-75)	Requires immediate action by senior management with a compulsory plan of measures and appointment of responsible persons. If necessary, stop of work.
High (25-54)	Requires attention of senior management. Urgently inform employees and their direct supervisors, the head of the relevant unit and the head of the occupational safety service. Take measures to ensure the safety of employees.
Medium (10-24)	Inform employees and directors, the head of the relevant unit and the head of the occupational safety service. Take risk mitigation measures.
Low (1-9)	It is managed through the implementation of existing procedures. Usually no additional resources are needed. Inform the head of the relevant unit and the head of the occupational safety service of the completion of the risk assessment work.

It is necessary to determine whether the degree of risk of a dangerous situation has become acceptable, i.e. whether the measures implemented have the expected effect.

RISK ASSESSMENT MAP

Card №											Date:			
Fulfilled by:											Date:			
Approved: Head of the OS service														
«___» _____ 20__ .														
RISK ASSESSMENT MAP														
Process:														
Operation:														
Staff involved:											Requirements of PEE:			
Action	Source of hazard	Possible consequences	Level of risk	Subject, taking risk	Existing measures to prevent the risk occurrence	Assessment of baseline risk				Suggested preventive actions	Assessment of residual risk			
						Probability (H _s)	Severity (S)	Possibility of infection (P)	Baseline risk degree		Probability (H _s)	Severity (S)	Possibility of infection (P)	Overall score
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

TOPIC #4: ESTIMATION OF WORK ZONE AIR PARAMETERS

Purpose of this work: to obtain the necessary practical skills for the ability to evaluate hygienic working conditions by the factors of the air of the working area.

PART 1

Statement

At workplace, temperature (t , °C), relative humidity (W ,%) and air velocity (V , m/s) were measured, there is also information on workplace characteristics, employees energy consumption, and measurement dates.

Task

To evaluate hygienic working conditions on workplace, according to the initial data, *table 4.7*.

1. to obtain hygienic working conditions parameters;
2. to determine according to the received initial data whether the obtained results correspond to the normative values of the working area and make the appropriate conclusions.

Report

1. student's first name, family name, group and variant using *table 4.5*;
2. the category of works;
3. the period of the year in which the microclimate parameters were measured;
4. optimum and valid values of air temperature: $t = \dots \text{ }^{\circ}\text{C}$;
5. optimum and valid values of relative humidity: $W = \dots \%$;
6. optimum and valid values of air velocity: $V = \dots \text{ m/s}$;
7. compare the determined microclimate parameters with the optimum and valid values;
8. general conclusion about the compliance of the determined microclimate parameters with the normative values

To define the category of works according to employees energy consumption use *table 4.1*.

To define the period of the year note that for most regions of Ukraine, the average daily ambient air temperature is above + 10 ° C between April 15 and October 15, from October 15 till April 15, this temperature is + 10 ° C and below. Write warm or cold for your variant.

Compare the determined microclimate parameters with the optimum or valid values according to *Tables 4.2 and 4.3*.

Write down the range of values by which you want to increase or decrease the actual value.

Note. Optimal air parameters are set for permanent workplaces. In this paper, permissible air parameters are established for non-permanent jobs.

Do a general conclusion about the compliance of the determined microclimate parameters with the normative values.

Categories of work

Type of work	Work category	energy consumption, W (kcal / h)	Characteristics of works
Light physical work	Ia	105–140 (90–120)	Work that is performed sitting down and does not require physical exertion
	Ib	141–175 (121–150)	Work performed while sitting, standing, or walking is accompanied by some physical strain
Medium physical work	IIa	176–232 (151–200)	Work related to walking, moving small (up to 1 kg) items or items in a standing or sitting position and requiring a certain physical strain.
	IIb	232–290 (201–250)	Work performed standing, on knitted with walking, moving not large (up to 10 kg) loads, and so is accompanied by moderate physical stress.
Heavy physical work	III	291–349 (251–300)	Work related to constant movement, transfer of significant fractions of weight (more than 10 kg) of goods that require a lot of physical effort.

PART 2

Statement

At one of the workstations were measured concentrations of harmful substances in the air of the work area.

Task

To determine whether the air quality meets the requirements of the interstate standard, according to the initial data, *table 4.7*.

Report

1. student's first name, family name, group and variant using *table 4.5*;
2. the values of the Threshold limit value (TLV) for harmful substances according to your variant and the specific features of the action: $TLV = \dots \text{mg} / \text{m}^3$;
3. comparing the actual concentrations of harmful substances with the Threshold limit value of these substances;
4. find out if there are any unidirectional substances among certain substances;
5. general conclusion about the compliance of air quality with the regulatory values

For finding Threshold limit value for harmful substances use *table 4.4*. Comparing the actual concentrations of harmful substances with the Threshold limit value of these substances note that actual concentrations should be lesser than Threshold limit value.

If any of your harmful substances share same specific features of the action they called unidirectional. If such substances are present, determine whether the conditions by formula:

$$C_1 / TLV_1 + C_2 / TLV_2 + \dots + C_n / TLV_n \leq 1 \text{ are satisfied.} \quad (4.1)$$

Note. If a substance has a complex harmful effect on humans (causing several diseases at the same time), then this substance will be unidirectional with all others if they have at least one identical harmful effect (cause the same disease), ie the same substance may be unidirectional with several others.

Table 4.2

Optimal values of temperature, relative humidity and air velocity in the working area of industrial premises

The period of the year	Category of works *	Air temperature, °C	Relative humidity, %	Air velocity, m/s.
Cold period	Light Ia	22 - 24	60 - 40	0,1
	Light Ib	21 - 23	60 - 40	0,1
	Medium IIa	19 - 21	60 - 40	0,2
	Medium IIb	17 - 19	60 - 40	0,2
	Heavy III	16 - 18	60 - 40	0,3
Warm period	Light Ia	23 - 25	60 - 40	0,1
	Light Ib	22 - 24	60 - 40	0,2
	Medium IIa	21 - 23	60 - 40	0,3
	Medium IIb	20 - 22	60 - 40	0,3
	Heavy III	18 - 20	60 - 40	0,4

*Category of work - the class of works by weight based on the total energy consumption of the organism.

Table 4.3

Valid values of temperature, relative humidity and air velocity in the working area of industrial premises

The period of the year	Category of works *	Air temperature, °C		Relative humidity, %	Air velocity, m/s.
		At permanent workplaces*	At non-permanent workplaces**		
Cold period	Light Ia	21-25	18-26	75	<= 0,1
	Light Ib	20-24	17-25	75	<= 0,2
	Medium IIa	17-23	15-24	75	<= 0,3
	Medium IIb	15-21	13-23	75	<= 0,4
	Heavy III	13-19	12-20	75	<= 0,5
Warm period	Light Ia	21-25	18-26	75	<= 0,1
	Light Ib	22-28	20-30	55 - at 28° C	0,2 - 0,1
	Medium IIa	21-28	19-30	60 - at 27° C	0,3 - 0,1
	Medium IIb	18-27	17-29	65 - at 26° C	0,4 - 0,2
	Heavy III	15-27	15-29	70 - at 25° C	0,5 - 0,2

*Permanent Workplace - a place where the employee is working more than 50% of the working time or more than 2 hours continuously. If the work is carried out in different points of the work area, then this whole area is considered a permanent workplace.

**Non-permanent workplace - a place where the employee is working less than 50% of the working time or less than 2 hours continuously.

Table 4.4

Threshold limit value (TLV) of hazardous substances in the air of the work area

Name of the substance	TLV, mg / m ³	Danger class	Aggregate condition	Features of the action
Aluminum	2	3	aerosol	Fibrogenic action
Ammonia	20	4	vapor	Irritation of mucous membranes, upper respiratory tract
Acetone	200	4	vapor	Narcotic effect, lesions of the central nervous system
Gasoline	100	4	vapor	Narcotic effect, lesions of the central nervous system
Nickel	0,05	1	aerosol	Carcinogenic and allergic effects
Asbestos dust	2	3	aerosol	Fibrogenic and allergenic action
Dust of cement	6	4	aerosol	Fibrogenic action
Plumbum	0,01	1	vapor	The gastrointestinal tract, liver, kidneys are affected; changes in blood and bone marrow; the brain is affected
Methyl alcohol	5	3	vapor	Narcotic effect, lesions of the central nervous system
Phenol	0,3	2	vapor	Allergic effect, skin and eye protection required

Student _____ Group _____ Variant _____

PART 1

Date of measurement	
Characteristics of the workplace	
Energy consumption of the organism	
Category and subcategory of works (determine)	
Season (determine warm or cold)	

Microclimate parameter		passed / dispassed (required) *	Conclusions **	
Name	Value			

$t, ^\circ\text{C}$	actual			Increase value by	
				Decrease value by	
	Optimal (determine)				
	Acceptable (determine)				

$W, \%$	actual			Increase value by	
				Decrease value by	
	Optimal (determine)				
	Acceptable (determine)				

$V, \text{m/s}$	actual			Increase value by	
				Decrease value by	
	Optimal (determine)				
	Acceptable (determine)				

General conclusions

* By the characteristics of the workplace

** Determine the actual difference from the normalized value

Student _____ Group _____ Variant _____

PART 2

1. Determine whether the actual concentration of each substance satisfies the following standards:

The name of the substance	Actual Concentration, mg / m ³	TLV mg / m ³	The multiplicity of excess TLV	Features of the action	Class and degree of working conditions
1					
2					
3					
4					

2. Determine the presence of unidirectional substances:

List of unidirectional substances	Checking for unidirectional substances (substitute the values in the formula $C_1 / TLV_1 + C_2 / TLV_2 + \dots + C_i / TLV_i =$)	Satisfies / does not meet the actual concentration standards (must be entered)

General conclusion	
--------------------	--

Table 4.7

INITIAL DATA FOR PART 1

Variant №	Date of measurement	Characteristics of the workplace	Energy consumption of the organism	t °C,	W, %,	V, m / s,
1	02.08	permanent	265	24	70	0,1
2	12.11	not permanent	170	25	60	0,4
3	17.04	permanent	140	27	65	0,3
4	01.11	permanent	110	18	37	0,2
5	15.06	permanent	230	25	39	0,4
6	13.04	permanent	190	22	61	0,4
7	19.09	not permanent	275	24	76	0,2
8	16 10	not permanent	169	18	70	0,4
9	31.08	not permanent	145	27	62	0,4
10	01 01	permanent	160	20	62	0,1
11	14.05	permanent	130	27	65	0,3
12	02.12	not permanent	95	20	75	0,1
13	29.05	permanent	210	25	38	0,4
14	20.10	permanent	115	19	39	0,3
15	05.08	not permanent	260	24	78	0,2
16	10.01	not permanent	90	25	77	0,1
17	30.05	not permanent	135	27	62	0,1
18	09.02	not permanent	155	25	60	0,2
19	17.05	permanent	265	27	55	0,2
20	28.02	permanent	120	18	37	0,2
21	12.08	not permanent	240	30	73	0,1
22	28.12	permanent	165	22	61	0,4
23	18.04	permanent	290	22	65	0,3
24	30.12	not permanent	100	25	77	0,2
25	01 06	permanent	225	25	62	0,3
26	19.09	permanent	145	28	65	0,1
27	02.10	not permanent	260	30	76	0,4
28	12.04	permanent	110	21	45	0,2
29	01.07	not permanent	220	25	73	0,3
30	01.10	not permanent	135	25	64	0,1

INITIAL DATA FOR PART 2

Variant №	Fact. conc., mg/m ³	Substance	Variant №	Fact. conc., mg/m ³	Substance	Variant №	Fact. conc., mg/m ³	Substance
1	0,5	Aluminum	11	2,1	Aluminum	21	2	Aluminum
	0,03	Nickel		0,06	Nickel		0,1	Nickel
	0,8	Asbestos dust		1,1	Asbestos dust		0,3	Asbestos dust
	5	Dust of cement		5	Dust of cement		1	Dust of cement
2	1	Aluminum	12	2	Aluminum	22	4	Aluminum
	1	Asbestos dust		1	Asbestos dust		0,5	Asbestos dust
	3	Dust of cement		5	Dust of cement		3	Dust of cement
	0,01	Plumbum		0,02	Plumbum		0,03	Plumbum
3	2	Aluminum	13	1,8	Aluminum	23	4	Aluminum
	0,06	Nickel		0,07	Nickel		0,2	Nickel
	1	Asbestos dust		1,5	Asbestos dust		0,5	Asbestos dust
	0,02	Plumbum		0,01	Plumbum		0,04	Plumbum
4	8	Ammonia	14	19	Ammonia	24	15	Ammonia
	80	Gasoline		95	Gasoline		60	Gasoline
	6	Dust of cement		5	Dust of cement		4	Dust of cement
	4,5	Methyl alcohol		5	Methyl alcohol		7	Methyl alcohol
5	21	Ammonia	15	13	Ammonia	25	3	Ammonia
	100	Acetone		167	Acetone		200	Acetone
	5	Methyl alcohol		4	Methyl alcohol		6	Methyl alcohol
	0,4	Phenol		0,4	Phenol		0,5	Phenol
6	20	Ammonia	16	18	Ammonia	26	10	Ammonia
	4	Asbestos dust		3	Asbestos dust		2	Asbestos dust
	6	Dust of cement		5	Dust of cement		2	Dust of cement
	0,2	Phenol		0,5	Phenol		0,15	Phenol
7	5	Ammonia	17	17	Ammonia	27	10	Ammonia
	230	Acetone		201	Acetone		20	Acetone
	25	Gasoline		74	Gasoline		10	Gasoline
	2	Methyl alcohol		6	Methyl alcohol		4,5	Methyl alcohol
8	60	Acetone	18	195	Acetone	28	40	Acetone
	50	Gasoline		10	Gasoline		87	Gasoline
	1,5	Methyl alcohol		4	Methyl alcohol		3,5	Methyl alcohol
	0,5	Phenol		0,3	Phenol		0,1	Phenol
9	7	Ammonia	19	18	Ammonia	29	4	Ammonia
	140	Acetone		78	Acetone		90	Acetone
	2	Dust of cement		5	Dust of cement		3	Dust of cement
	3	Methyl alcohol		5,5	Methyl alcohol		6	Methyl alcohol
10	150	Acetone	20	190	Acetone	30	100	Acetone
	65	Gasoline		81	Gasoline		25	Gasoline
	3	Asbestos dust		1	Asbestos dust		2	Asbestos dust
	6	Dust of cement		3	Dust of cement		4	Dust of cement

TOPIC #5: AIR QUALITY REGULATION

Purpose of this work: to obtain the necessary practical skills for the ability to normalize the microclimate and heat protection of the human body and evaluate hygienic working conditions by the factors of the air of the working area.

Statement

In a public building, there are rooms for various purposes, where people work and relax. The size and purpose of the room, orientation of windows, number and energy consuming of employees, number of equipment and electrical power given in the source data.

Task

To evaluate hygienic working conditions on workplace, according to the initial data, **table 5.5**.

1. to calculate the power of the "split" air conditioner that needs to be installed in a public building for cooling during the warm season;
2. to calculate the required number of radiator sections for room heating during the cold season.

Report

1. student's first name, family name, group and variant using **table 5.4**;
2. external heat inflow: $Q_e = \dots W$;
3. release of heat from equipment: $Q_o = \dots W$;
4. heat output from the workers depending on the energy consuming: $Q_w = \dots W$;
5. desired power of the split air conditioner: $Q_x = \dots W$;
6. amount of heat that is lost by a building: $Q_b = \dots W$;
7. relative water consumption per equivalent m^2 : $q = \dots kcal / h$;
8. value of the equivalent m^2 : $q_{em2} = \dots kcal / h$;
9. required surface of the devices equivalent: $F_d = \dots m^2$;
10. required number of radiator sections: $n_d = \dots m^2$.

The choice of a "split" air conditioner is carried out by power (cooling), considering all heat spills-external, from the equipment and workers.

To calculate external heat inflow Q_e use the formula:

$$Q_e = q_o \cdot V, \quad (5.1)$$

where $q_o = 40$, for the South orientation, $q_o = 30$, for the North, the average value of $q_o = 35$ (depends on the azimuth of light apertures, considering that the North is span from 0^0 to 45^0 , and from 315^0 to 360^0 , South – from 135^0 to 225^0 , and everything else – average), W/m^3 ;

V – room volume, m^3 :

$$V = a \cdot b \cdot h, \quad (5.2)$$

To calculate release of heat from equipment Q_o use the formula:

$$Q_o = 0,3 \cdot P + n_k \cdot Q_{ok}, \quad (5.3)$$

where $0,3 \cdot P$ - for electrical appliances, where P – rated power, W ;

n_k – number of office equipment units;

$Q_{ok} = 300$ approximately for a personal computer and copier, W .

To calculate heat output from the workers depending on the energy consuming Q_w use the formula:

$$Q_w = n_w \cdot Q_{ow}, \quad (5.4)$$

where n_w – number of employees;

Q_{ow} – energy consumption of the body, W .

Note: 1 kcal / h = 1.167 W

Make an approximate calculation of the desired power (Q_x) of the split air conditioner using the formula:

$$Q_x = Q_e + Q_o + Q_w, \quad (5.5)$$

The amount of heat that is lost by a building structure Q_b depends on the temperature difference, their values, the area and type of material, and can be calculated for flat surfaces using the formula:

$$Q_b = k \cdot F_c \cdot (t_{in} - t_{out}), \quad (5.6)$$

where k – coefficient of heat transfer of the fence structure (walls), depends on the material from which the walls are built, for this problem we assume $k = 0,92 \text{ kcal/h} \cdot \text{m}^2 \cdot \text{°C}$;

t_{in} – the normalized room temperature, $^{\circ}\text{C}$ (*table 5.3*);

Note. For this problem, we calculate the arithmetic mean between the upper and lower limits of the norm

t_{out} – the estimated outdoor temperature, which is taken from climate data for a given city, $^{\circ}\text{C}$ (for Kyiv, $t_{out} = -16^{\circ}\text{C}$);

F_c – the surface of the enclosing structure through which heat is lost m^2 :

$$F_c = a \cdot h. \quad (5.7)$$

The heating surface of heating devices, which gives off heat, is determined in equivalent square meters (e. m^2), and then listed on the meter of the types of devices accepted for installation. We determine the relative water consumption per e. m^2 , will be:

$$q = \frac{7,98(\Delta t - 10)}{\Delta T_{\text{device}} \cdot L}, \quad (5.8)$$

where Δt – the temperature difference between the average temperature of the heat carrier in the heating device and the room temperature, $^{\circ}\text{C}$:

$$\Delta t = \frac{t_{st} + t_{end}}{2} - t_{in}, \quad (5.9)$$

ΔT_{device} – temperature difference of the heat carrier in the heating device, °C.

$$\Delta T_{\text{device}} = t_{st} - t_{end}, \quad (5.10)$$

water with the initial temperature $t_{st} = +100$ °C and the final $t_{end} = +60$ °C

L – the amount of water supplied from top to bottom, $L = 17.4$, $kg / m^2 \cdot h$.

The value of the $e. m^2$ can be calculated using the formula:

$$q_{e.m2} = 7,98(\Delta t - 10) \cdot \alpha, \quad (5.11)$$

where α – the correction coefficient that depends on the relative water consumption (*table 7.1*).

Table 5.1

q	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	5	7	>7
α	0.85	0.89	0.91	0.93	0.95	0.97	0.99	1	1.03	1.06	1.07

Note. For this task, if the q value is from 0.525 to 0.575, we take $\alpha = 0.92$.

The required surface of the devices $e. m^2 F_d$ can be determined by the formula:

$$F_d = \frac{Q_k}{q_{ekm}}. \quad (5.12)$$

The required number of radiator sections M-140 ($f_{e.k.m.} = 0.31 m^2$) is:

$$n_d = \frac{F_{np}}{f_{ekm}}, \quad (5.13)$$

Note. The required number of radiator sections must be an integer.

Table 5.2

Categories of work

Type of work	Work category	energy consumption, W (kcal / h)	Characteristics of works
Light physical work	Ia	105–140 (90–120)	Work that is performed sitting down and does not require physical exertion
	Ib	141–175 (121–150)	Work performed while sitting, standing, or walking is accompanied by some physical strain
Medium physical work	IIa	176–232 (151–200)	Work related to walking, moving small (up to 1 kg) items or items in a standing or sitting position and requiring a certain physical strain.
	IIb	232–290 (201–250)	Work performed standing, on knitted with walking, moving not large (up to 10 kg) loads, and so is accompanied by moderate physical stress.
Heavy physical work	III	291–349 (251–300)	Work related to constant movement, transfer of significant fractions of weight (more than 10 kg) of goods that require a lot of physical effort.

Table 5.3

Optimal values of temperature, relative humidity and air velocity in the working area of industrial premises

The period of the year	Category of works *	Air temperature, °C	Relative humidity, %	Air velocity, m/s.
Cold period	Light Ia	22 - 24	60 - 40	0,1
	Light Ib	21 - 23	60 - 40	0,1
	Medium IIa	19 - 21	60 - 40	0,2
	Medium IIb	17 - 19	60 - 40	0,2
	Heavy III	16 - 18	60 - 40	0,3
Warm period	Light Ia	23 - 25	60 - 40	0,1
	Light Ib	22 - 24	60 - 40	0,2
	Medium IIa	21 - 23	60 - 40	0,3
	Medium IIb	20 - 22	60 - 40	0,3
	Heavy III	18 - 20	60 - 40	0,4

Student _____ Group _____ Variant _____

Choice of a "split" air conditioner

$Q_e = q_o \cdot V =$	=	
$Q_o = 0,3P + n_k Q_{ok} =$	=	
$Q_w = n_w Q_{ow} =$	=	
$Q_x = Q_e + Q_o + Q_w =$	=	

Required number of radiator sections

$Q_b = k \cdot F_c (t_{in} - t_{out}) =$	=	
$F_c = a \times h =$	=	
$q = \frac{7,98(\Delta t - 10)}{\Delta T_{device} \cdot L} =$	=	
$\Delta t = \frac{t_{st} + t_{end}}{2} - t_{in} =$	=	
$\Delta T_{device} = t_{st} - t_{end} =$	=	
$q_{e,m2} = 7,98(\Delta t - 10) \cdot \alpha =$	=	
$F_{np} = \frac{Q_k}{q_{ekm}} =$	=	
$n_{np} = \frac{F_{np}}{f_{ekm}} =$	=	

Table 5.5

INITIAL DATA

№ option	Purpose of the room	Size of room			Azimuth of light openings	Number of employees	Energy consumption of the body, kcal / h	Office equipment (nk, units)	Power of electrical equipment P, W
		<i>a</i>	<i>b</i>	<i>h</i>					
1	workshop	10	7	2,7	42°	4	153	1	1050
2	office	6	5,4	3,2	12°	4	136	5	315
3	auditorium	12	7	3,2	122°	16	104	12	1350
4	workshop	21	8	3	341°	8	211	2	2000
5	office	5,9	3,2	3	212°	3	107	3	150
6	workshop	15	6	2,8	98°	2	175	2	600
7	room of protection	5,3	3,6	2,8	32°	2	95	2	350
8	auditorium	9,8	5,5	3,7	109°	12	100	10	1260
9	laboratory	5,9	3,9	3	266°	3	91	0	420
10	workshop	18	7	2,9	185°	5	198	2	1100

TOPIC #6: ASSESSMENT OF PARAMETERS OF INDUSTRIAL LIGHTING

PART 1

Purpose of this work: to obtain the necessary practical skills for the ability to estimate the actual hygienic working conditions for lighting by calculation methods.

Statement

In a production room with a length of a m, a height of h m and a width of 6 m, work is carried out in which the minimum size of the distinguished object is s_0 mm. The room has a common lighting system, illuminated by N two-lamps type LED, which are placed in **two** rows and in each of which are fluorescent lamps with a power of **40** watts. The ceiling of the premises is fresh white $\rho_c = 70\%$, the walls are light gray $\rho_w = 50\%$, the floor of oak $\rho_f = 30\%$. The height of the working surface h_w is 0.8m.

Task

To evaluate lighting system at the room, according to the initial data, *table 6.5*.

1. to draw the layout of the lamps in the room;
2. to determine the normalized value of illumination;
3. to determine the actual value of illumination;
4. to determine whether or not the illumination in this room corresponds to the normative values.

Report

1. student's first name, family name, group and variant using table 6.4;
2. draw the layout of the lamps in the room according to the original data, indicating the size of the room, the length of the lamps, the distance between rows and between the lamps;
3. the normalized value of illumination in the workplace: $E_n = \dots lx$;
4. the actual illumination in the room: $E_a = \dots lx$;
5. compare the actual value of the illumination created in the room with the normative;
6. in case the room lighting does not meet the standards, calculate the required number of luminaires and draw the layout of their location.

To determine the distance between the rows, the following rule should be considered: the distance from the wall to the lamp is half the distance between the rows. To determine the distance between luminaires it is necessary to determine the sum of the lengths of all luminaires in a row, to find the difference between this length and the length of the room. Further, according to rule that the luminaires should be spaced evenly along the row, that is, all gaps should be the same, make a preliminary calculation of the distance between the luminaires and between the luminaire and the wall. Find the sum of the distances obtained between the luminaires in a row, to which add the sum of the lengths of all the luminaires, and then find the difference between the obtained value and the length of the wall. Divide this difference in half to find the final distance from the wall to the lamp.

To determine the normalized value of illumination determine the category of visual works using minimum size of recognitions object **so**, and based on the backgrounds and contrasts characteristics determine the subcategory of visual works (**Tab. 6.1**).

Then using same **table 6.1** determine the normalized value of illumination - E_n for the installed lighting system, type of lamps, category and subcategory of visual work, knowing that P for the visual work category II is 10, for the III - V categories – 40.

To determine the actual illumination first find value of luminous flux F_l , lm emitted by each of the lamps on the basis of the type and power of the lamps using **Tab. 6.2**. Then calculate the room index i according to the formula:

$$i = a \cdot b / (h_c \cdot (a + b)), \quad (6.1)$$

where a and b are the length and width of the room, h_c - the distance between the lamp and the work surface ($h_c = h - h_w$).

Note: the thickness of the luminaires is neglectful in this task.

Based on the room index i and the coefficients of reflection of the ceiling, walls and floor (ρ_c, ρ_w, ρ_f), determine the luminous flux coefficient η (Tab. 6.3);

Note: index i should be rounded down to the closest value.

Calculate value of the actual illumination using the formula:

$$E_a = F_l \cdot N \cdot n \cdot \eta / (S \cdot k \cdot z), \quad (6.2)$$

where F_l - luminous flux of the lamp, lm,

N - number of luminaires, units,

n - number of lamps in the luminaire, units,

η - luminous flux coefficient,

S - area of the room, m²,

k – reserve coefficient,

z - irregularity coefficient.

Note: Consider the reserve coefficient k of 1.5 for this task and a irregularity coefficient z of 1.1.

To compare the actual value of the illumination with the normative value keep in mind that this task allows deviation of the actual value from the normative by 10% in the smaller direction, or by 20% - in the larger one, the decrease in illumination is unacceptable from the hygienic point of view, the increase is economically impractical.

Table 6.1

Characteristic of visual work	The smallest or equivocal size of the object of distinction, mm	Category of visual work	Sub category of visual work	Contrast between the object and the background	Characteristic of the background	Artificial lighting					Natural lighting		Combined lighting	
						Illumination, lx			set of normalized values of the blindnesses value and the ripple coefficient		Natural Light Ratio, e_n , %			
						Combined lighting system		General lighting system			in upper or combination lighting	in lateral lighting	in upper or combined lighting	in lateral lighting
						Total	Part of total		P	K, %				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Highest accuracy	Less than 0.15	I	a	Small	Dark	5000 4500	500 500	—	20 10	10 10	—	—	6.0	2.0
			б	Small Average	Average Dark	4000 3500	400 400	1200 1000	20 10	10 10				
			в	Small Average	Bright Average	2500 2000	300 200	750 600	20 10	10 10				
				Big	Dark	1500 1250	200 200	400 300	20 10	10 10				
Very high accuracy	From 0.15 to 0.3	II	a	Small	Dark	4000 3500	400 400	—	20 10	10 10	—	—	4.2	1.5
			б	Small Average	Average Dark	3000 2500	300 300	750 600	20 10	10 10				
			в	Small Average	Bright Average	2000 1500	200 200	500 400	20 10	10 10				
				Big	Dark	1000 750	200 200	300 200	20 10	10 10				

Table 6.1 (cont.)

High accuracy	From 0.3 to 0.5	III	a	Small	Dark	2000 1500	200 200	500 400	40 20	15 15	—	—	3.0	1.2
			б	Small Average	Average Dark	1000 750	200 200	300 200	40 20	15 15				
			в	Small Average Big	Bright Average Dark	750 600	200 200	300 200	40 20	15 15				
			г	Average Big Big	Bright Bright Average	400	200	200	40	15				
Average accuracy to 1.0	More than 0.5	IV	a	Small	Dark	750	200	300	40	20	4	1.5	2.4	0.9
			б	Small Average	Average Dark	500	200	200	40	20				
			в	Small Average Big	Bright Average Dark	400	200	200	40	20				
			г	Average Big Big	Bright Bright Average	—	—	200	40	20				
Small accuracy	From 1.0 to 5	V	a	Small	Dark	400	200	300	40	20	3	1	1.8	0.6
			б	Small Average	Average Dark	—	—	200	40	20				
			в	Small Average Big	Bright Average Dark	—	—	200	40	20				
			г	Average Big Big	Bright Bright Average	—	—	200	40	20				
Rough	More than 5	VI		—		—	—	200	40	20	3	1	1.8	0.6

Table 6.1 (end.)

Working with materials, which are glowing, and products in hot shops	More than 5	VII		—	—	—	200	40	20	3	1	1.8	0.6
General monitoring of the production process: - constant		VIII	a	—	—	—	200	40	20	3	1	1.8	0.6
- periodic with permanent stay of people in the room			б	—	—	—	100	—	—	1	0.3	0.7	0.2
- periodic with periodic stay of people in the room			в	—	—	—	50	—	—	0.7	0.2	0.5	0.2
- general observation of engineering communications			г	—	—	—	20	—	—	0.3	0.1	0.2	0.1

Table 6.2

Specifications of low pressure fluorescent lamps

Lamp type	Power, W	Grid voltage on lamp, V	Luminous flux rate, lm	Lamp size, mm		Cap	Lifespan, hours	Color temperature, K
				Length	Diameter			
865 (ЛДЦ) 20 765 (ЛД) 20 635 (ЛБ) 20 640 (ЛХБ) 20 530 (ЛТБ) 20 840 (ЛЕЦ) 20	20	220/57	820 920 1020 1200 1200 865	589,8	38	G13d/35	10000	6500 4000 3450 2950
865 (ЛДЦ) 40 765 (ЛД) 40 640 (ЛХБ) 40 635 (ЛБ) 40 530 (ЛТБ) 40 965 (ЛДЦУ) 40 840 (ЛЕЦ)40 840 (ЛЕЦ) 40 927 (ЛТБЦ) 40	40	220/103	2100 2340 3100 3200 3150 1560 2190 1930 1700	1199,4	38	G13d/35	10000	6500 4000 3450 2950
865 (ЛДЦ) 65 765 (ЛД) 65 640 (ЛХБ) 65 635 (ЛБ) 65 530 (ЛТБ) 65 840 (ЛЕЦ) 65	65	220/110	3050 3870 3820 4800 3980 3400	1500,0	38	G13d/35	10000	6500 4000 3450
865 (ЛДЦ) 80 765 (ЛД) 80 640 (ЛХБ) 80 635 (ЛБ) 80 530 (ЛТБ) 80	80	220/102	3740 4070 4440 5400 4440	1500,0	38	G13d/35	10000	6500 4000 3450 2950

Table 6.3

The light flux coefficient

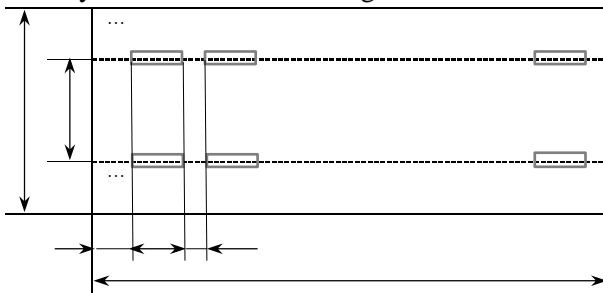
ρ_c	0.7	0.7	0.5	0.5	0
ρ_w	0.5	0.5	0.5	0.3	0
ρ_f	0.3	0.1	0.1	0.1	0
i	η				
0.5	0.23	0.20	0.20	0.17	0.10
0.6	0.28	0.26	0.24	0.20	0.14
0.7	0.32	0.30	0.28	0.24	0.17
0.8	0.35	0.33	0.30	0.26	0.19
0.9	0.38	0.35	0.33	0.29	0.21
1.0	0.41	0.38	0.35	0.31	0.23
1.1	0.43	0.40	0.37	0.33	0.25
1.25	0.45	0.41	0.38	0.35	0.27
1.5	0.49	0.45	0.42	0.38	0.30
1.75	0.52	0.47	0.44	0.41	0.32
2.0	0.54	0.49	0.45	0.42	0.33
2.25	0.56	0.51	0.47	0.44	0.35
2.5	0.58	0.52	0.48	0.46	0.36
3.0	0.60	0.54	0.50	0.48	0.38
3.5	0.62	0.55	0.51	0.49	0.39
4.0	0.64	0.56	0.52	0.50	0.40
5.0	0.67	0.59	0.54	0.53	0.43

Student _____ Group _____ Variant _____

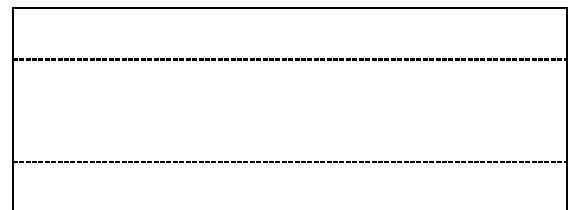
Output data:	
The length of the room a , m	
The width of the room b , m	
Room height h , m	
Working surfaces height h_w , m	
The minimum size of the distinguished object s₀ , mm	
Background characteristic	
Contrast between the object and the background	
Ceiling reflection coefficient ρ_c	
Wall reflection coefficient ρ_w	
Floor reflection coefficient ρ_f	
N two-tube (n = 2) LED lamps (40W lamps)	
Type of lamps	
reserve coefficient (k)	
irregularity coefficient (z)	
Calculations:	
2.1. category of visual works (table 5.1)	
2.2. the normalized value of illumination in the workplace E_n , lx.	
3.1. the luminous flux emitted by each of the lamps, F_l , lm (table 5.2)	
lamp length, mm *	
3.2. the room index i according to the formula $i = a \cdot b / (h_c \cdot (a + b)) =$	
The distance between working place and ceiling h_c = h - h_w	
3.3. luminous flux coefficient η (table. 3)	
3.4. actual illumination $E_a = F_l N n \eta / (S k z) =$	
Room space S =	
4. $((E_n - E_a) / E_n) * 100\% =$	
5. Conclusion (Satisfies whether or not the premises meet the task requirements)	
Calculate the number of luminaires N_p required to achieve the optimal illumination value (must be an even number) $N_p = S k z E_n / F_l n \eta =$	
Calculate the illumination with the optimum number of lamps $E_p = F_l N_p n \eta / S k z =$	
Calculate the percentage at the optimum number of fixtures	

* We accept 1200 mm for this task.

The layout of the fixtures in a given room:



The actual location of the lamps



Estimated location of lamps

INITIAL DATA FOR THE INDUSTRIAL LIGHTING EVALUATION

Variant	Room parameters, m			Characteristic of visual work			Quantity of lamps, N, 40 Вт	lamp type
	<i>a</i>	<i>h</i>	<i>b</i>	Minimum size of recognition object, мм	Background characteristics	Contrast between the object and the background		
1	8	3	6	0.2	Average	Small	6	635 (ЛБ)
2	12	4	6	0.4	Average	Average	8	765 (ЛД)
3	16	5	6	0.8	Bright	Big	10	865 (ЛДЦ)
4	20	3	6	3	Dark	Big	14	635 (ЛБ)
5	8	4	6	0.2	Average	Small	6	765 (ЛД)
6	12	5	6	0.4	Bright	Small	8	865 (ЛДЦ)
7	16	3	6	0.8	Dark	Average	12	635 (ЛБ)
8	20	4	6	3	Average	Big	14	765 (ЛД)
9	8	5	6	0.2	Bright	Big	4	865 (ЛДЦ)
10	12	3	6	0.4	Dark	Small	8	635 (ЛБ)

PART 2

Purpose of this work: to obtain the necessary practical skills for the ability to estimate the actual hygienic working conditions for lighting by calculation methods.

Statement

A natural light study was conducted in a production facility located in Kyiv with windows along one of the larger sidewalls. The parameters of the room and the category of visual work are similar to those given in part 1 (*Tab. 6.1*). For this purpose, the value of natural light was measured at workplaces located at a distance of 1, 2, 3, 4 and 5 m from the window.

Task

To evaluate lighting system at the production room, according to the initial data, *table 9.8*.

1. to determine the value of the normalized Natural Light Ratio;
2. to determine the value of the actual Natural Light Ratio;
3. to build a graph of the Natural Light Ratio depending on distance from the window;
4. to compare whether or not the Natural Light Ratio in this room meets the normative values of the natural light of the work area;
5. to make judgments about compliance with the normative values of indoor workplaces and measures to improve working conditions in rooms where actual Natural Light Ratio does not meet the standards.

Report

1. student's first name, family name, group and variant using *table 9.7*;
2. normalized Natural Light Ratio for the premises specified in the conditions: $e_n = \dots$;
3. the value of the actual Natural Light Ratio at each point at which the value of natural light was measured: $e_a = \dots$;
4. build a graph of the actual Natural Light Ratio from the distance to the window and draw a line of normalized Natural Light Ratio values for the premises;
5. determine whether or not the Natural Light Ratio in this room meets the normative values of the natural illumination of the work area;
6. if the Natural Light Ratio in the room does not meet the regulatory requirements, find the approximate distance from the window where area with satisfactory natural light ends. Tick these areas in the space plan.

To determine normalized Natural Light Ratio e_n use Table 6.1 for day lighting system based on the category and subcategory of visual work.

Determine the coefficient of light climate m_N due to Table 6.6 based on the location of the room, the orientation of its windows beyond the horizon.

Using the formula calculate the normalized Natural Light Ratio value for a given room

$$e_N = e_n \cdot m_N, \quad (6.3)$$

To determine the value of the actual Natural Light Ratio use the formula

$$e_a = (E_{in} / E_{out}), \quad (6.4)$$

Note: in the case of lateral natural light systems, the minimum value of the Natural Light Ratio is normalized, which is determined at a point 1 m from the wall opposite to the light apertures.

Table 6.6

Coefficient of light climate

Light slots	Orientation of light openings on the sides of the horizon	Coefficient of light climate, m_N	
		Crimea, Odesa	Rest of Ukraine
In the outer walls of houses	N	0.85	0.90
	NE, NW	0.85	0.90
	W, E	0.80	0.85
	SE, SW	0.80	0.85
	S	0.75	0.85
In rectangular and trapezoidal lanterns	NS	0.80	0.80
	NE NW, SW NW	0.75	0.80
	EW	0.70	0.75
In lanterns	N	0.80	0.80
In the zenith lights	-	0.70	0.80

Note: N - north; NE - northeast; NW - northwest; E - east; W - west; NS - north-south; EW - east-west; S - south; SE - southeast; SW - southwest

Student _____ Group _____ Variant _____

Magnitude of natural light E_{in} , lx, on the distance L , m, from the window					Orientation of windows beyond the horizon	Exterior illumination, E_{out} , lx
1	2	3	4	5		

Calculations:

II.1. 1. $e_n =$ for _____ illumination

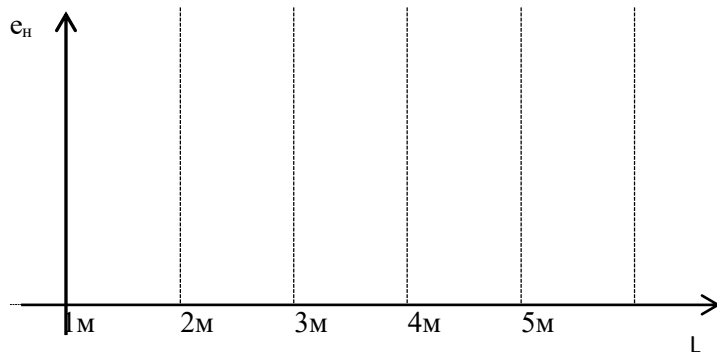
II. 1.2. $m_N =$

II. 1.3. $e_N = e_h m_N =$

II. 2. $e_a = (E_{in} / E_{out}) 100\%$

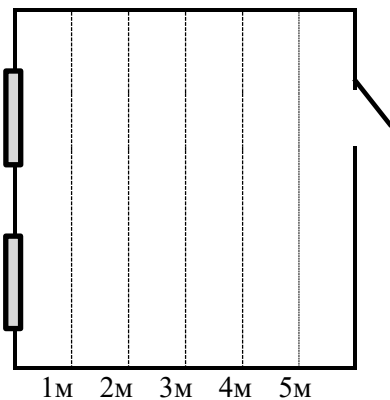
Distance from the window, m	1	2	3	4	5
Natural Light Ratio (e), %					

3. Graph of the dependence of Natural Light Ratio on the distance to the window L .



4. In this room, Natural Light Ratio (meets / does not meet) regulatory values.

5. Area of the premises for which the actual Natural Light Ratio does not meet the normative value (mark by hatching on the plan of the premises)



6. General conclusions on the practical work:

To achieve ambient light in the workplace the following steps should be taken (write down all possible options):

INITIAL DATA FOR THE NATURAL LIGHTING EVALUATION

Variant	Magnitude of natural light E_{in} , lx, on the distance L , m, from the window					Orientation of windows on the sides of the horizon	Exterior illumination E_{out} , lx
	1	2	3	4	5		
1	2000	1520	1010	675	450	North	16000
2	1540	1100	780	560	400	East	20000
3	1160	860	640	470	350	West	25000
4	1520	1010	675	450	300	South	30000
5	2300	1650	1180	840	600	North	35000
6	2320	1720	1280	945	700	East	40000
7	1270	845	565	375	250	West	15000
8	770	550	390	280	200	South	20000
9	1830	1350	1000	745	550	North	25000
10	2530	1690	1120	750	500	East	30000

TOPIC #7: EVALUATION OF THE ELECTRICAL SAFETY

Purpose of this work: to get acquainted with the causes of electric shock and the factors that affect its consequences.

Statement

The person came under the voltage of a short three-phase industrial network. Line voltage of the network (U_l), leakage resistance of phase conductors in it ($r_a = r_b = r_c = r$), resistance of functional grounding of the neutral of the network with grounded transformer neutral (R_g), transient resistance at the ground fault (R_t). The resistance of the body of the person under voltage (r_l), the material of the sole of his shoe are known, and the type of the supporting surface of the feet (soil or floor) is also known. Because the network is short, capacitors of phase conductors relative to the ground can be neglected

Task

To evaluate electrical safety of the person, according to the initial data, *table 7.6*.

1. to determine current that will flow through the person in different cases;
2. to determine voltage applied to the person in different cases;
3. to compare the results of the calculations and evaluate the danger of switching on the network with isolated and deaf grounded transformer in different network modes.

Report

1. student's first name, family name, group and variant using table 7.5;
2. electrical resistance of the shoes: $r_s = \dots \Omega$;
3. electrical resistance of the support surface of the feet on the floor: $r_f = \dots \Omega$;
4. electrical resistance of human circuit: $r_h = \dots \Omega$;
5. current that will flow through the person: $I_h = \dots A$;
6. voltage applied to the person: $U_h = \dots V$;
7. possible effect of such current and voltage on the person;

The equivalent electrical resistance of the shoe is equal to half the resistance of one sole of the shoe (*table 7.1*), since these resistances are connected in parallel:

$$r_s = r'_s / 2. \quad (7.1)$$

The electrical resistance of the support surface of the feet on the floor depends on the material and the humidity of the floor. The values of the floor areas resistance are shown in the *table 7.2*.

The electrical resistance of the support surface of the feet on the soil depends on the type and humidity of the soil. The resistance of the current from the support surface of two feet is determined by the formula:

$$r_f = 0,022 \cdot \rho, \quad (7.2)$$

where ρ - soil resistivity according to the *table 7.3*, $\Omega \cdot m$.

Determine the electrical resistance of the human circuit r_h , which, in the case of a single-phase connection to the network, is equal to the sum of the resistance of the human body r_l , the resistance of the sole of the shoe r_s and the resistance of the surface on which the person stands (floor or soil) r_f :

$$r_h = r_l + r_s + r_f, \quad (7.3)$$

Determine the magnitude of the current in each of the six cases listed below:

1. single phase touch in normal mode with isolated transformer neutral

$$I_h^{11} = \frac{U_p}{r_h + \frac{1}{3}}; \quad (7.4)$$

2. single phase emergency mode touch with isolated transformer neutral

$$I_h^{12} = \frac{U_p}{r_h + R_p}; \quad (7.5)$$

3. two-phase touch with isolated transformer neutral

$$I_h^{13} = \frac{U_l}{r_l}; \quad (7.6)$$

4. single phase touch in normal mode with grounded transformer neutral

$$I_h^{21} = \frac{U_p}{r_h + R_p}; \quad (7.7)$$

5. single phase emergency mode touch with grounded transformer neutral

$$I_h^{22} = U_p \frac{R_g + \sqrt{3}R_p}{R_g R_p + r_h(R_g + R_p)}; \quad (7.8)$$

6. two-phase touch with grounded transformer neutral

$$I_h^{23} = \frac{U_l}{r_l}; \quad (7.9)$$

Determine the voltage applied to the person in each of these cases using the formula:

$$U_h = I_h \cdot r_l. \quad (7.9)$$

Using the tables 7.4-6 show the possible result of the action of such current and voltage on the person.

Table 7.1

Electrical resistance of the shoes

Shoe sole	Humidity	Resistance, $\kappa\Omega$, at voltage, V.			
		under 65	127	220	over 220
Leather	dry	200	150	100	50
Fabrikoid		150	100	50	25
Rubber		500	500	500	500
Leather	wet	1,6	0,8	0,5	0,2
Fabrikoid		2,0	1,0	0,7	0,5
Rubber		2,0	1,8	1,5	1,0

Table 7.2

Electrical resistance of the support surface of the feet

Floor material	Resistance, $\kappa\Omega$			Floor material	Resistance, $\kappa\Omega$,		
	dry	wet	moist		Dry	wet	moist
Metal	0,01	0	0	Wood	30	3	0,3
Brick	10	1,5	0,8	Linoleum	1500	50	4
Ground	20	0,8	0,3	Concrete	2000	0,9	0,1
Broom tile	25	2	0,3	Asphalt	2000	10	0,8

Table 7.3

Soil electrical resistivity

Soil	Electrical resistivity, $\Omega \cdot m$,		Recommended for grounding calculations, $\Omega \cdot m$
	dry	wet	
Peat	-	16	20
Black soil	50	16	30
Garden soil	60	30	50
Clay	65	13	60
Loam	160	40	100
Susand	400	160	300
Sand	2500	500	2500
Angular rock, Asphalt	2300	1200	2000
Rocky soil	2700	1600	2000
Freezing soil	3000	1300	-

Table 7.4

Electric current thresholds

Currents characteristic	Currents, mA	
	Variable at 50 Hz	constant
Threshold tangible current	0,5 – 1,5	5 – 7
Threshold non-releasing current	10 – 15	50 – 80
Threshold fibrillation current	50 – 80	300

Student _____ Group _____ Variant _____

Var.	U _l , V	r, κΩ	R _p , Ω	R _g , Ω	r _l , Ω	Shoe sole	Supporting surface of the feet	
							floor	Soil

1. Equivalent electrical resistance of the shoe (*table 7.1*):

$$r_s = r'_s / 2 =$$

2. Electrical resistance of the support surface:

$$r_f =$$

3. Electrical resistance of the human circuit:

$$r_h = r_l + r_s + r_f, =$$

Neut ral mode	Type of Touch		Current, A	Voltage, V	The type of the currents effect
Isolated	single phase touch in normal mode		$I_h^{11} = \frac{U_p}{r_h + \frac{r}{3}} =$		
	single phase emergency mode touch		$I_h^{12} = \frac{U_p}{r_h + R_g} =$		
	two-phase touch		$I_h^{13} = \frac{U_l}{r_l} =$		
Grounded	single phase touch in normal mode		$I_h^{21} = \frac{U_p}{r_h + R_p} =$		
	single phase emergency mode touch	Exact formula	$I_h^{22} = U_p \frac{R_g + \sqrt{3}R_g}{R_n R_p + r_h(R_n + R_p)} =$		
		Approximate formula	$I_h^{22\delta} = \frac{U_p}{r_h} =$		
	two-phase touch		$I_h^{23} = \frac{U_l}{r_l} =$		

Table 7.6

INITIAL DATA

Variant	U _l , V	r, κΩ	R _p , Ω	R _g , Ω	r _i , Ω	Shoe sole	Supporting surface of the feet	
							floor	soil
1	660	50	1,5	100	2000	Leather d.	Brick d.	
2	660	60	2,0	110	1000	Leather w.	Brick w.	
3	660	70	2,5	120	1800	Fabrikoid d.	Wood d.	
4	660	80	3,0	150	1700	Fabrikoid w.	Wood w.	
5	660	90	3,5	180	1600	Leather d.	Linoleum w.	
6	220	100	4,0	200	1500	Leather w.	Linoleum m.	
7	220	110	4,5	220	1400	Fabrikoid d.	Concrete w.	
8	220	120	5,0	250	1300	Fabrikoid w.		Black soil d.
9	220	130	5,5	280	1200	-		Black soil w.
10	220	140	6,0	300	1100	-		Clay d.
11	380	150	6,5	100	1100	Rubber d.		Clay w.
12	380	160	7,0	110	900	Leather w.		Loam d.
13	380	170	7,5	120	800	Leather d.		Loam w.
14	380	180	8,0	150	700	Fabrikoid d.		Susand d.
15	380	190	2,0	180	600	Fabrikoid w.		Susand w.
16	660	200	2,5	200	600	-		Sand d.
17	660	210	3,0	220	700	-		Sand w.
18	660	220	3,5	250	800	Leather d.		Asphalt d.
19	660	230	4,0	280	900	Leather w.		Asphalt w.
20	660	240	4,5	300	1000	Fabrikoid d.		Angular rock d.
21	220	250	5,0	100	1100	Fabrikoid w.		Angular rock w.
22	220	280	5,5	150	1400	Leather d.	Wood d.	
23	220	290	6,0	180	1500	Leather w.	Wood w.	
24	220	300	6,5	200	1600	Fabrikoid d.	Linoleum d.	
25	220	310	7,0	220	1700	Fabrikoid w.	Linoleum m.	
26	220	320	7,5	250	1800	Rubber w.	Linoleum w.	

Note: "d" – dry, "w" – wet, "m" – moist

TOPIC #8: EVALUATION OF FIRE SAFETY

Purpose of this work: obtain the necessary practical skills to be able to choose the class and type of fire extinguishers and determine their number and capacity to ensure the required level of fire safety of production facilities.

Statement

In a production room with knowing area, and certain explosive and fire hazard category, fire of certain class is started.

Task

To calculate fire protection system at the production room, according to the initial data, *table 8.3*.

1. to choose class and type of fire extinguishers;
2. to determine number of fire extinguishers;
3. to determine capacity of fire extinguishers;

Report

1. student's first name, family name, group and variant using table 8.4;
2. class and type of fire extinguishers;
3. number of fire extinguishers;
4. capacity of fire extinguishers;

Depending on the aggregate state and the characteristics of combustion of various combustible substances and materials, fires are divided into appropriate classes and subclasses:

class A - burning of solids, whether or not accompanied by (subclass A1) smoldering;

class B - combustion of insoluble liquid substances (subclass B1) and soluble (subclass B2) in water;

class C - gas combustion;

class D - combustion of light metals with the exception of alkali (subclass D1), alkali metals (subclass D2) and metal-containing compounds (subclass D3);

class E - burning of electrical installations under voltage.

In addition to the above parameters, the category of premises for explosive and fire hazard is also taken into account.

The category of fire danger of premises (buildings, structures) is a classification characteristic of fire danger of an object, which is determined by the quantity and fire hazardous properties of substances and materials that are (rotate) in them, taking into account the peculiarities of technological processes of their production.

According to ДСТУ Б.Б.1.1.- 36:2016 the premises for explosive and fire danger are divided into five categories (A, Б, В, Г, Д). The qualitative criterion of explosive danger of premises (buildings) is the presence in them of substances with certain indicators of explosive danger. A qualitative criterion for determining the category is excess pressure (P), which can develop with explosive ignition of the maximum possible accumulation (loading) of explosive substances in the room.

Category A (explosive) - flammable gases premises, flammable liquids with a flash point of not more than 28 °C in such quantities that explosive vapor-air cymes can be formed, when the estimated excess explosion pressure in the room exceeds 5 kPa. Substances and materials capable of explosion and combustion by contact with water, oxygen or with each other in such a way that the estimated excess explosion pressure in the room exceeds 5 kPa.

Category Б (Explosive) - premises using explosive dust and fibers, flammable liquids with a flash point greater than 28 °C and flammable liquids under temperature conditions and in such quantities that explosive dust or steam air cysts can form, when calculating, exceeding 5kPa.

Category В (fire hazard) - premises containing flammable liquids, solid flammable and combustible substances, materials capable of combining with water, oxygen or air only if the premises in which they are or are used do not fall into categories A and Б and specific fire load for solid and liquid flammable, combustible and combustible substances and / or materials in individual areas with an area of not less than 10 m².

Category Г (moderate fire) - premises containing non-combustible substances and materials in hot, hot or melted state, the process of which is accompanied by the emission of radiant heat, icop, flames, as well as combustible liquids, combustible gases, solids that are burned or disposed of as fuels.

Category Д (Low Fire) - premises containing the substances and / or materials listed above for category В (excluding combustible gases, combustible dust and / or fibers), as well as non-combustible substances and / or materials in the cold state (at ambient temperature), conditions that the premises in which the substances and / or materials mentioned above are stored (stored, processed, transported) do not fall into categories A, Б or В.

** Notes: 1. Specific fire load is a fire load per unit of area of production of materials and materials that are rotated in production, including process equipment, cables (insulation), and substances and materials in storage rooms, furniture, etc. capable of burning*

2. Fire load is the amount of heat that can be released indoors in the event of complete combustion of substances and materials in production, including process equipment, cables (insulation), and in the case of complete combustion of substances and materials in in warehouses, furniture, etc. that are capable of burning.

According to the method of transportation of the extinguishing agent, fire extinguishers are produced in two types: portable - fig. 2 (volume 1 - 10 l, total weight no more than 20 kg) and mobile fig. 3 (larger than 25 liters, mounted on special frames with wheels).

The choice of the type of fire extinguisher is determined by the size of the possible fire. With the large size of the latter it is recommended to install mobile extinguishers.

The ejection of an extinguishing agent from the extinguisher can be accomplished by creating excess pressure: a propellant gas contained in a separate subcompact cylinder, and it can be placed both inside and outside the extinguisher housing; extruder gas contained in the fire extinguisher housing (injection); gas formed as a result of a chemical reaction.

Depending on the extinguishing agents used, the extinguishers are divided into the following types: foam, gas and powder.

Foam fire extinguishers are used in Class A and B fires to extinguish solid and liquid combustible materials, with the exception of substances that burn without access to air or which can burn and explode when interacting with foam and live electrical equipment.

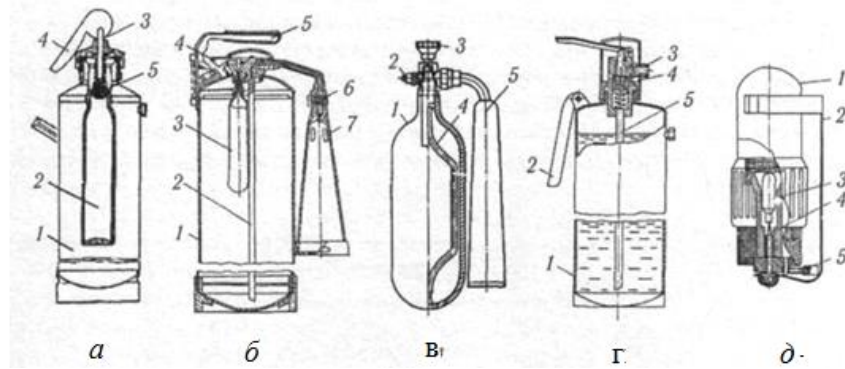


Fig. 8.1. Portable fire extinguishers:

a - fire extinguisher chemical foam BXII-10: 1 - frame; 2 - glass; 3 - locking device; 4 - starting lever; 5 - shut-off valve; *б* - fire extinguisher air-foam BIII-10: 1 - frame; 2 - siphon tube; 3 - balloon; 4 - starting lever; 5 - handle; 6 - spray; 7 - diffuser with mesh; *в* - carbon dioxide extinguisher BB-2: 1 - balloon; 2 - safety valve; 3 - the valve; 4 - siphon tube; 5 - diffuser-snowmaker; *г* - carbon dioxide-bromethyl fire extinguisher BBБ-3А: 1 - cylinder; 2 - handle; 3 - spray nozzle; 4 - cap; 5 - siphon tube; *д* - powder fire extinguisher БП-1 "Moment": 1 - frame; 2 - safety bracket; 3 - a can of carbon dioxide; 4 - needle; 5 - spray with plastic cap.

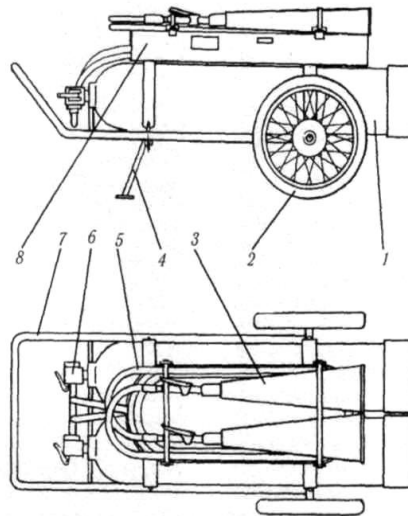


Fig. 8.2. Mobile BB-80 extinguisher:

1- balloon; 2 - wheel; 3 - bell; 4 - support; 5 - hose; 6 - locking mechanism; 7 - frame; 8 - casing

According to the method of foam formation, foam extinguishers are divided into chemical foam and air-foam.

Due to the limited scope, inconvenience of keeping foam fire extinguishers in standby, etc. their output is greatly reduced.

At present, powder fire extinguishers are more sophisticated and in line with trends in the development of fire extinguishing agents. They can be used in class A, B, C, D i E fires to extinguish

fires of solids, liquids, gases and electrical equipment up to 1000 V. Powder fire extinguishers are available in two types: with starter cylinder and injection.

In fire extinguishers with a starting cylinder (ОП-2, ОП-5Б, ОП-5М, ОП-9, ОП-50), the housing containing the starting cylinder with gas or air under pressure is filled with extinguishing powder.

Carbon dioxide extinguishers produce three types: BB-2, BB-5 and BB-8 (figures show the capacity of the cylinder in liters). They are used for Class A, B and E fires to extinguish solids and liquids (such as those that can burn without access to air), as well as electrical installations that are energized up to 1000 V, provided that the conductive parts are not closer to the distance 1 m

The carbon dioxide-bromethyl fire extinguishers of BBБ-3 and BBБ-7 differ little from carbon dioxide in appearance and construction. They are charged with a mixture of 97% ethyl bromide and 3% carbon dioxide. Due to the high wettability of ethyl bromide, the performance of these extinguishers is 4 times higher than that of carbon dioxide. Due to the high toxicity of ethyl bromide, these extinguishers are of limited use and are used mainly in Class B, C, and E fires.

The choice of the **class** and **type** of fire extinguishers and the determination of their number and capacity is made depending on their extinguishing ability, boundary area, class of fire in the room or object in need of protection in accordance with applicable standards (ДСТУ 3675-98, ISO 3941-2007). In addition to the above parameters, the category of premises for explosive and fire hazard is also taken into account. The following tables (table 8.1) and (table 8.2) provide recommendations for the fitting out of production premises with portable and mobile fire extinguishers in accordance with the existing requirements of the regulatory documents.

Table 8.1

Recommendations for the installation of portable fire extinguishers									
Room category	The maximum protected area, m ²	Fire classes	Chemical foam fire extinguishers 10 l.	Powder extinguishers, capacity, l			Chladon fire extinguishers 2 (3) l.	Carbon dioxide extinguishers, capacity, l	
				2	5	10		2(3)	5(8)
A, Б, В (flammable gases and liquids)	200	A	2++	-	2+	1++	-	-	-
		B	4+	-	2+	1++	4+	-	-
		C	-	-	2+	1++	4+	-	-
		D	-	-	2+	1++	-	-	-
		(E)	-	-	2+	1++	-	-	2++
B (except combustible gases and liquids)	400	A	2++	4+	2++	1+	-	-	2+
		D	-	-	2+	1++	-	-	-
		(E)	-	-	2++	1+	2+	4+	2++
Г	800	B	2+	-	2++	1+	-	-	-
		C	-	4+	2++	1+	-	-	-
Г, Д	1800	A	2++	4+	2++	1+	-	-	-
		D	-	-	2+	1++	-	-	-
		(E)	-	2+	2++	1+	2+	4+	2++
Public buildings and structures	800	A	4++	8+	4++	2+	-	-	4+
		(E)	-	-	4++	2+	4+	4+	2++

Table 8.2

Recommendations for the installation of mobile fire extinguishers							
Room category	Boundary protected area, m ²	Fire class	Air-foam fire extinguishers with capacity 100 l.	Combined fire extinguishers (foam, powder) with capacity 100 l	Powder extinguishers capacity 50 (100) L	Carbon dioxide extinguishers, capacity, l	
						25 (40)	80
A, B, B (combustible gases and liquids)	500	A	1++	1++	1++	-	3+
		B	2+	1++	1++	-	3+
		C	-	1+	1+	-	3+
		D	-	-	1++	-	-
		(E)	-	-	1+	2+	1++
B (except combustible gases and liquids)	800	A	1++	1++	1++	4+	2+
		B	2+	1++	1++	-	3+
		C	-	1++	1+	-	3+
		D	-	-	1++	-	-
		(E)	-	-	1+	1+	1+

* Notes: 1. The maximum area of a possible bonfire of Class A and B fires in premises where the use of extinguishers is intended shall not exceed the extinguishing capacity of the extinguishers used.

2. "++" - marked fire extinguishers recommended for equipment of objects; the sign "+" - fire extinguishers, the use of which is possible only in the absence of recommended fire extinguishers and in the presence of appropriate justification; the sign "-" means fire extinguishers, which are not allowed to equip objects.

It should also be noted that premises equipped with stationary automatic fire extinguishing installations are allowed to be supplied with fire extinguishers for 50% of their estimated quantity.

According to the initial data, choose the type and type of fire extinguishers and determine their number to provide the required level of fire safety at the production site.

* Notes: 1. To determine the type (manual, portable), type (foam, powder, carbon dioxide, chladone), capacity and quantity of extinguishers, use tables 8.1 and 8.2.

2. Record the results in table 8.3.

3. In addition to 1 specified variant, to propose, if possible, 2 and 3 variants of equipment for the production room with fire extinguishers.

Table 8.3

Citation number	Explosive and fire hazard category	Fire Class	The total area of the production premises, m ²
№ 1	B (combustible gases and liquids)		
№ 2	B (except combustible gases and liquids)	E	380
№ 3	A	B	190
№ 4	B (except combustible gases and liquids)	A	800
№ 5	A (except combustible gases and liquids)	C	500
№ 6	A (except combustible gases and liquids)	B	1000
№ 7	B (except combustible gases and liquids)	B	2000
№ 8	Г (excluding flammable gases and liquids).	C	790

Student _____ Group _____ Variant _____

Cituation number	Class of fire extinguisher	Specification of fire extinguisher	The capacity of the fire extinguisher (l)	Number of fire extinguishers (pcs.)	Notes
№ 1					
Variant 1					
Variant 2					
Variant 3					
№ 2					
Variant 1					
Variant 2					
Variant 3					
№ 3					
Variant 1					
Variant 2					
Variant 3					
№ 4					
Variant 1					
Variant 2					
Variant 3					
№ 5					
Variant 1					
Variant 2					
Variant 3					
№ 6					
Variant 1					
Variant 2					
Variant 3					
№ 7					
Variant 1					
Variant 2					
Variant 3					
№ 8					
Variant 1					
Variant 2					
Variant 3					

TOPIC #9: PROTECTIVE SHELTER RELIABILITY EVALUATION

Purpose of this work: to obtain the necessary practical skills for the ability to evaluate protective shelters reliability by calculation methods.

Statement

As a result of an accident at the neighboring industrial unit the staff of the machine-building plant may be found at the contaminated area (chemical, radioactive contamination etc.).

To prevent staff affection two protective shelters were built at the territory of the machine-building plant.

Task

To evaluate protective shelters reliability according to the initial data listed in the *table 9.1*:

1. to determine if there would be enough place for the staff in the both protective shelters;
2. to determine if ventilation and air cleaning systems maintain air feed continuity according to the current specification;
3. to determine if water supply is sufficient in the both protective shelters.

Report

1. student's first name, second name, group and variant;
2. seating capacity calculated for the area index: $M_{A1} = \dots \text{persons};$
 $M_{A2} = \dots \text{persons};$
3. seating capacity calculated for the volume index: $M_{V1} = \dots \text{persons};$
 $M_{V2} = \dots \text{persons};$
4. minimum seats amount in the protective shelters: $M_{min1} = \dots \text{persons};$
 $M_{min2} = \dots \text{persons};$
5. actual seats number in the both protective shelters : $M_1 = \dots \text{persons};$
 $M_2 = \dots \text{persons};$
6. number of the seats in the 1st air duty: $N^1_1 = \dots \text{persons};$
 $N^1_2 = \dots \text{persons};$
7. number of the seats in the 2nd air duty: $N^2_1 = \dots \text{persons};$
 $N^2_2 = \dots \text{persons};$
8. number of the seats in the 3rd air duty: $N^3_1 = \dots \text{persons};$
 $N^3_2 = \dots \text{persons};$
9. number of the seats supplied by the water: $N_{w1} = \dots \text{persons};$
 $N_{w2} = \dots \text{persons};$

To obtain *seating capacity calculated for the area index* it's necessary to use formula 9.1:

$$M_A = \frac{S_{sh}}{S_{nor}} , \quad (9.1)$$

where: M_A - seating capacity calculated for the area index;

S_{sh} – area of the protective shelter facility, m²;

S_{nor} - space requirements (per person) :

$S_{nor} = 0.5 \text{ m}^2$, if floor-to-ceiling height is 2.15 - 2.9 m, and

$S_{nor} = 0.4 \text{ m}^2$, if floor-to-ceiling height is more than 2.9 m).

To obtain *seating capacity calculated for the volume index* it's necessary to use formula 9.2:

$$M_V = \frac{(S_{sh} + S_{ad}) \cdot h}{V_{nor}} , \quad (9.2)$$

where: M_V - seating capacity calculated for the volume index;

S_{sh} – area of the protective shelter facility, m² ;

S_{ad} – area of additional protective shelter facility, m²;

h - floor-to-ceiling height, m;

V_{nor} - air volume requirements (per person) : $V_{nor} \geq 1.5 \text{ m}^3$.

To obtain *number of the seats in the 1st air duty* it's necessary to use formula 9.3:

$$N_1 = \frac{n \cdot V_1}{W_1} , \quad (9.3)$$

where: N_1 - number of the seats in the 1st air duty;

n – number of filter installations FU-1 and/or FU-2 in the protective shelter;

V_1 – productivity of filter installation in the 1st air duty, m³/hour ;

W_1 - air volume requirements (per person) m³/hour; depends on the climatic region, where the machine-building plant is situated:

I climatic region – 8 m³/hour ;

II climatic region - 10 m³/hour ;

III climatic region - 11 m³/hour ;

IV climatic region - 13 m³/hour .

To obtain *number of the seats in the 2nd air duty* it's necessary to use formula 9.4:

$$N_2 = \frac{n \cdot V_2}{W_2} , \quad (9.4)$$

where: N_2 - number of the seats in the 2nd air duty;

n – number of filter installations FU-1 and/or FU-2 in the protective shelter;

V_2 – productivity of filter installation in the 2nd air duty, m³/hour ;

W_2 - air volume requirements (per person) m³/hour, for the 2nd air duty,

$W_2 = 2$ m³/hour;

To obtain number of the seats in the 3rd air duty it's necessary to use formula 9.5:

$$N_3 = 150 \cdot m, \quad (9.5)$$

where: N_3 - number of the seats in the 3rd air duty;

m – number of filter units FU-2 in the protective shelter.

To obtain number of the seats supplied by the water it's necessary to use formula 9.6:

$$N_w = \frac{B}{B_{nor} \cdot T}, \quad (9.6)$$

where: N_w - number of the seats supplied by the water;

B - emergency water ration, liters;

B_{nor} - water requirements (per person), liters;

T – estimated time of the protective sheltering, days.

Table 9.1

No	Parameters	1	2	3	4	5	6	7	8	
1	Manning level, persons	310	340	400	450	480	550	620	670	
2	Characteristics of the protective shelters									
	a) area of the protective shelter facility, m ²	Shelter 1	80	100	104	152	160	152	122	230
		Shelter 2	75	80	75	62	78	130	130	105
	b) area of additional protective shelter facilities, m ²	Shelter 1	10	30	27	53	35	46	34	67
		Shelter 2	30	24	10	9	25	26	64	26
	c) floor-to-ceiling height, m	Shelter 1	2,5	2,2	3	2,2	2,5	2,2	3	2,3
		Shelter 2	2,3	2,4	2,5	3,2	2,3	2,6	2,4	2,5
3	Number and modification of filter units	Shelter 1	1 FU-1	1 FU-1	2 FU-1	2 FU-2	2 FU-1	2 FU-1	2 FU-1	3 FU-1
		Shelter 2	1 FU-1	1 FU-1	1 FU-2	1 FU-2	1 FU-1	2 FU-1	2 FU-1	1 FU-1
4	Climatic region	III	II	III	II	I	IV	III	II	
5	Carbon monoxide gassing	no	no	No	yes	no	no	no	no	
6	Emergency water ration, liters	Shelter 1	1200	900	2800	1800	2800	1600	2700	2700
		Shelter 2	1200	850	1200	750	1300	1500	2800	1200
7	Estimated time of the protective sheltering, days	3	2	3	2	3	2	3	2	

Table 9.1 (cont.)

No	Parameters	9	10	11	12	13	14	15	16	
1	Manning level, persons	750	890	920	950	305	370	420	465	
2 Characteristics of the protective shelters										
	a) area of the protective shelter facility, m ²	Shelter 1	240	310	227	154	76	77	122	154
		Shelter 2	80	150	225	242	78	108	60	75
	b) area of additional protective shelter facilities, m ²	Shelter 1	54	37	40	42	20	25	28	20
		Shelter 2	23	40	20	40	14	35	10	22
	c) floor-to-ceiling height, m	Shelter 1	3,1	2,6	2,5	2,3	2,4	2,2	3	2,6
		Shelter 2	2,2	2,4	2,8	3,2	2,5	2,3	2,5	2,4
3	Number and modification of filter units	Shelter 1	4 FU-2	4 FU-2	3 FU-1	2 FU-1	1 FU-2	1 FU-1	3 FU-1	2 FU-1
		Shelter 2	1 FU-2	2 FU-2	3 FU-1	4 FU-1	1 FU-2	1 FU-1	3 FU-1	4 FU-1
4	Climatic region	III	II	I	III	I	II	I	III	
5	Carbon monoxide gassing	yes	yes	no	no	yes	no	no	no	
6	Emergency water ration, liters	Shelter 1	4850	3500	3960	1750	1250	870	3960	1750
		Shelter 2	1300	1750	4000	3550	1300	1300	4000	3550
7	Estimated time of the protective sheltering, days		2	3	2	3	2	3	2	

Table 9.1 (end)

No	Parameters	17	18	19	20	21	22	23	24	
1	Manning level, persons	490	565	615	665	740	870	910	925	
2 Characteristics of the shelters										
	a) area of the protective shelter facility, m ²	Shelter 1	77	182	160	75	225	242	226	151
		Shelter 2	155	64	152	184	152	136	230	242
	b) area of additional protective shelter facilities, m ²	Shelter 1	25	36	55	20	30	48	47	38
		Shelter 2	26	15	36	42	36	46	69	58
	c) floor-to-ceiling height, m	Shelter 1	2,2	3,1	2,2	2,5	2,6	3,1	2,5	2,4
		Shelter 2	2,5	2,3	2,4	3	2,4	2,2	2,3	3
3	Number and modification of filter units	Shelter 1	1 FU-1	3 FU-2	2 FU-1	1 FU-1	3 FU-2	4 FU-1	3 FU-1	2 FU-1
		Shelter 2	2 FU-1	1 FU-2	2 FU-1	3 FU-1	2 FU-2	2 FU-1	3 FU-1	4 FU-1
4	Climatic region	I	II	III	I	II	IV	II	I	
5	Carbon monoxide gassing	no	yes	No	no	yes	no	no	no	
6	Emergency water ration, liters	Shelter 1	1300	2650	2700	800	3900	3500	4000	1750
		Shelter 2	1650	650	2650	2600	2500	1600	4100	3500
7	Estimated time of the protective sheltering, days	2	2	3	2	3	2	3	2	