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“IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE”

LABOUR PROTECTION AND CIVIL DEFENSE

PRACTICUM

Recommended by Igor Sikorsky KPI Academic Council as a tutorial for undergraduate students of specialties 152 “Metrology and information - measuring equipment” (educational program “Biomedical devices and information-measuring systems”) and 163 “Biomedical engineering” (educational program “Medical engineering”)

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Electronic network educational edition

Labour Protection and Civil Defense

PRACTICUM

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The tutorial is an instruction book for the implementation of 18 practices, which covers all sections of the discipline "Labour Protection and Civil Defense". 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 152 “Metrology and information - measuring equipment” (educational program “Biomedical devices and information-measuring systems”) and 163 “Biomedical engineering” (educational program “Medical engineering”).

CONTENTS

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 "Labour Protection and Civil Defense" was introduced starting from the 2017/18 academic year. Its structure allocates 36 hours of practice for students in engineering specialties (areas of training), which are not technologically dangerous.

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 18 instructions for practical works, which cover all sections of the discipline. Practical works are devoted to identify harmful and dangerous factors in the environment; their assessment for compliance with sanitary and hygienic norms and safety requirements, certification of workplaces; selection and operation of modern means of collective and individual protection; measures and means of fire safety; holding and registration of briefings on labor protection at workplaces; 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 AND PERSONALITY PROCESSES

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.

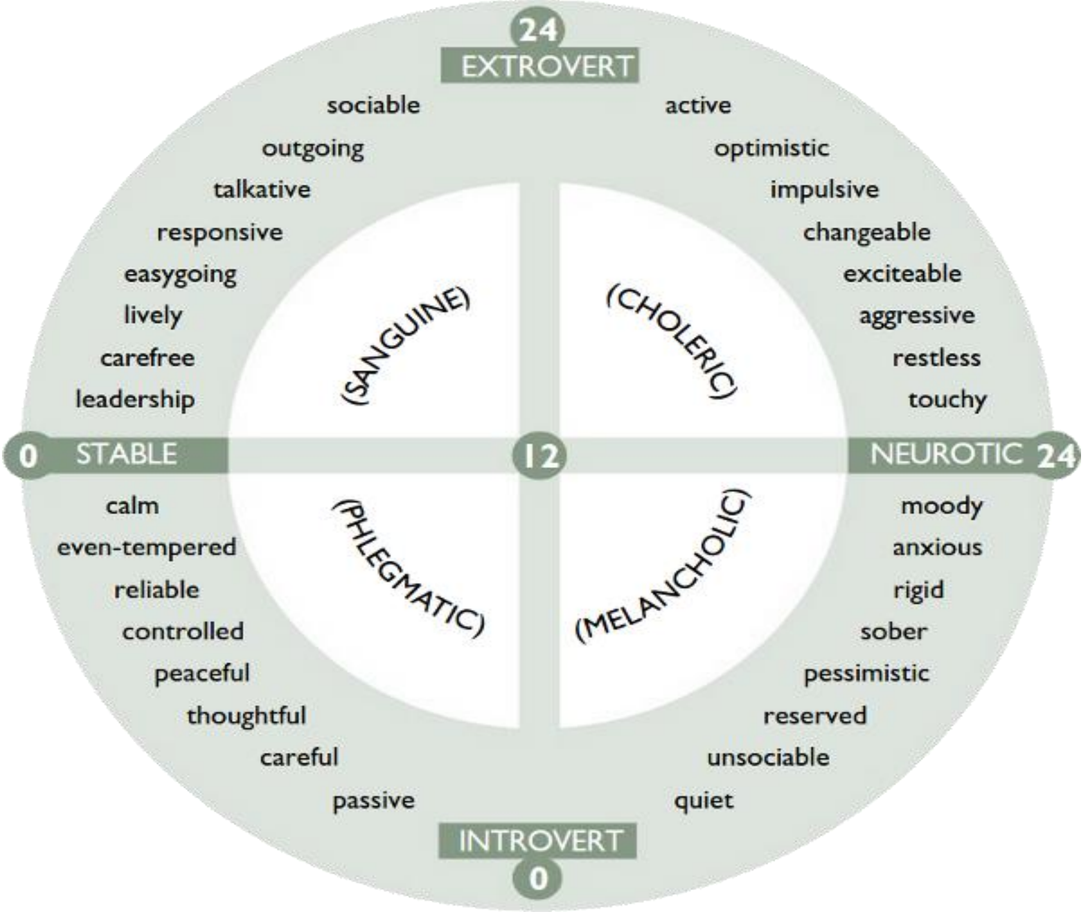


Fig. 1.1. Diagram for determining a person's temperament

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 otherpeople 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 feelingyou 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?		

32	If there is something you want to know about, would you rather look it upin 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: $\boldsymbol{R_1^*} = \ldots$;
3. risk of death during the year due to a possible industrial accident: $\boldsymbol{R_2^*} = \ldots$;
4. risk of life-threatening death during the year as a result of a possible accident in the home: $\boldsymbol{R_3^*} = \ldots$;
5. risk of being exposed to a life-threatening danger during the year due to its individual lifestyle: $\boldsymbol{R_4^*}$ and/or $\boldsymbol{R_4^{**}} = \ldots$;
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:

$$\boldsymbol{R_2^*} = \mathrm{T}_{\boldsymbol{w}} \cdot \boldsymbol{R_2} \frac{\mathrm{K}_{\boldsymbol{w}}}{\mathrm{K}_{\boldsymbol{m}}}, \tag{2.3}$$

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

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:

$$\boldsymbol{R_3^* = K_{cfa} \cdot R_3,} \tag{2.4}$$

where $\boldsymbol{R_3}$ - risk for a person of a certain age group (***Table 2.5***);

$\boldsymbol{K_{cfa}}$ - 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:

$$\boldsymbol{R_4^* = K_{cfd} \cdot R_4',} \tag{2.5}$$

where $\boldsymbol{R_4'}$ **-** risk of death of a person as a result of bad habits (***Table 13.6***);

$$\boldsymbol{R_4^{**} = K_{cfa} \cdot R_4'' \cdot T,} \tag{2. 6}$$

where $\boldsymbol{R_4''}$ **-** 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**	$8000*10^{-6}$	**2**	**Excessive alcohol consumption**	$212*10^{-6}$
		Non-productive risks			
1	Random drownings	$91*10^{-6}$	**6**	Occasional suffocation, obstruction of the respiratory tract	$58*10^{-6}$
2	Road Accidents	$190*10^{-6}$	**7**	Electric shock	$19*10^{-6}$
3	Household poisoning	$97*10^{-6}$	**8**	Suicide and self-harm	$258*10^{-6}$
4	Random falls	$62*10^{-6}$	**9**	Kills and willful damage	$117*10^{-6}$
5	Fire damage	$48*10^{-6}$	**10**	Effect of radon-222 contained in indoor air	$250*10^{-6}$

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

$$\boldsymbol{R} = \boldsymbol{R}_1^* + \boldsymbol{R}_2^* + \boldsymbol{R}_3^* + \boldsymbol{R}_4^* + \boldsymbol{R}_4^{**}, \tag{2. 7}$$

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 ($R<1*10^{-4}$)
2	**Relatively safe** (metallurgical workers, Shipbuilding, coal mining industry, Cast iron, pottery and ceramic Productions, industry in general, and civil aviation workers)	0,0001…0,0010 ($1*10^{-4}<R<1*10^{-3}$)
3	**Dangerous** (occupied by carbon dioxide and vulcanization Production, crew members of fishing trawlers, Construction workers, climbers, tractors)	0,0010…0,0100 ($1*10^{-3}<R<1*10^{-2}$)
4	**Particularly dangerous** (test pilots, members Crews of military helicopters, divers)	>0,0100 ($R>1*10^{-2}$)

Table 2.8

Student ____________________ Group __________ Variant __________

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

Table 2.8 (cont.)

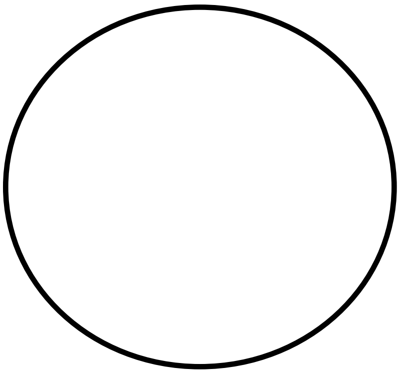
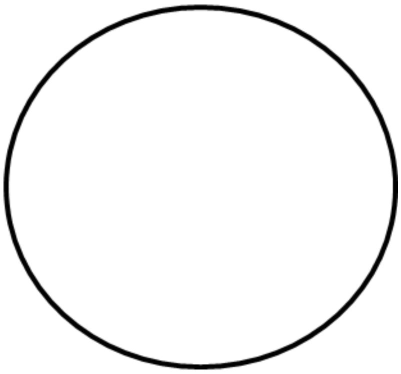
6. Diagram  7. Qualitative analysis of absolute values: Conclusions:	6. Diagram  7. Qualitative analysis of absolute values: Conclusions:

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	alpimism, 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 AT WORK

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 5.4) 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:

$$\mathbf{R} = \mathbf{S} \cdot \mathbf{P} \cdot \mathbf{H_s}, \qquad (3.1)$$

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 precious 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.

Table 3.5

RISK ASSESSMENT MAP

Card №

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: METHODS OF ANALYSIS OF INDUSTRIAL RISKS AND SAFETY LEVELS OD INDUSTRIAL EQUIPMENT, TECHNOLOGICAL PROCESSES AND WORKING CONDITIONS

Purpose of this work: to obtain the necessary practical skills to apply existing methods of analysis to determine the industrial risks and levels of safety of production equipment, technological processes and working conditions.

Statement

The concept of risk is a key factor in occupational safety, so it is important to know its meaning and to be able to use it. Production risk is the probability of an employee's health damage during the performance of their work duties, which is caused by the degree of harmfulness and (or) danger of working conditions and the scientific and technical state of production.

According to the Occupational Hygiene Classification, occupational risk is the magnitude of the probability of damage to health, taking into account the severity of the effects of adverse environmental factors and the work process.

Task

To evaluate safety levels and industrial risks of the production equipment, technological processes and working conditions, depending on the risk parameters, according to the initial data, ***table 4.2***.

1. to determine overall safety level;
2. to determine overall risk level;
3. to determine indicator of working conditions safety.

Report

1. student's first name, family name, group and variant using ***table 4.1;***
2. safety level of technological process: LS_I = **...** ;
3. safety level of production equipment: LS_{II} = **...** ;
4. safety level of work process: LS_{III} = **...** ;
5. overall safety level of working conditions: LS_{Σ} = **...** ;
6. overall risk level of harmful and dangerous production factors: LD_{Σ} = **...** ;
7. integral indicator of working conditions safety: b_0 = **...** ;

Frequency of occurrence of danger (p), is defined as the ratio of the number of events with certain consequences (n) to the maximum possible number (N) in a given period of time:

$$p = n/N, \qquad (4.1)$$

Comprehensive risk assessment is risk (R), which is defined as the product of the frequency of occurrence of a hazard to the harm it causes:

$$\boldsymbol{R = p/E}, \tag{4.2}$$

Since probability is a dimensionless dimension, it turns out that the units of risk and potential harm should be the same. If we are talking about the determination of damage (***E***) in monetary terms, then it will definitely be a monetary unit, if the danger of ionizing radiation, then the risk will be determined in units of absorbed dose, etc. Also, in some cases it is allowed to take ***E*** = 1.

Frequency of occurrence of periodic or accidental dangerous and harmful production factors (***p***) during technological processes can be determined by the following dependence:

$$\boldsymbol{p} = \frac{t}{T}, \tag{4.3}$$

where ***t*** - duration of the hazardous or harmful production factor during the technological process for a certain period of time;

T - defined period of time of the technological process.

The levels of safety of production equipment, technological processes and working conditions are determined taking into account existing methodological recommendations. The safety level of the process can be calculated by the formula:

$$\boldsymbol{LS_I} = 1 - \left(\frac{\sum_{i=1}^{n} t_i^I}{T^I} + \frac{\sum_{j=1}^{m} \tau_j^I}{T^I} + \frac{\sum_{k=1}^{p} \varphi_k^I}{T^I} \right), \tag{4.4}$$

where $\boldsymbol{LS_I}$ - safety level of technological process;

$\sum_{i=1}^{n} t_i^I$ - the total length of time during which the physicochemical parameters of the technological process deviated from the normalized values, with the determined expiration date of the technological process;

$\sum_{j=1}^{m} \tau_j^I$ - total length of time during which extreme (emergency) situations took place, with a defined expiration date of the technological process;

$\sum_{k=1}^{p} \varphi_k^I$ - the total length of time during which the physicochemical parameters of the technological process deviated from the normalized values under the influence of external factors or as a result of malfunctioning of the units, at a certain validity of the technological process;

$\boldsymbol{T^I}$ - defined duration of technological process (month, year, inter-repair period), for which violations (deviation of process parameters from normative values) and extreme situations (accidents) are taken into account.

The safety of production equipment is determined by its ability to maintain a safe state when performing specified functions under certain conditions for a specified time, the level of safety of production equipment can be calculated by the formula:

$$\boldsymbol{LS}_{\mathbf{II}} = 1 - \left(\frac{\sum_{i=1}^{n} t_i^{II}}{T^{II}} + \frac{\sum_{j=1}^{m} \tau_j^{II}}{T^{II}} \right), \quad (4.5)$$

where $\boldsymbol{LS}_{\mathbf{II}}$ - safety level of production equipment;

$\sum_{i=1}^{n} t_i^{II}$ - total operating time of the production equipment with violations of safety standards and rules with the specified term of operation of the production equipment;

$\sum_{j=1}^{m} \tau_j^{II}$ - total operating time of production equipment in the conditions of extreme (emergency) situations with the specified term of operation of production equipment;

$\boldsymbol{T^{II}}$ - defined the life of the production equipment (month, year, inter-repair period), which takes into account deviations in its operation, which lead to violations of safety rules and rules, and extreme (emergency) situations.

The safety level of the work process can be calculated by the formula:

$$\boldsymbol{LS}_{\mathbf{III}} = 1 - \left(\frac{\sum_{i=1}^{n} t_i^{III}}{T^{III}} \right), \quad (4.6)$$

where $\boldsymbol{LS}_{\mathbf{III}}$ - safety level of work process;

$\sum_{i=1}^{n} t_i^{III}$ - total time of performance of labor operations in the presence of dangerous and harmful production factors at the determined duration of the labor process;

$\boldsymbol{T^{III}}$ - duration of determined labor process.

The overall safety level of working conditions can be calculated by the formula:

$$\boldsymbol{LS}_{\Sigma} = \boldsymbol{LS}_{I} \cdot \boldsymbol{LS}_{II} \cdot \boldsymbol{LS}_{III}. \quad (4.7)$$

The overall risk level of harmful and dangerous production factors can be calculated by the following formula:

$$\boldsymbol{LD}_{\Sigma} = 1 - \boldsymbol{LS}_{\Sigma}. \quad (4.8)$$

Integral indicator of safety of working conditions ($\boldsymbol{b_0}$) is characterized by the ratio of the total amount of cases of dangerous and harmful factors occurring in the technological processes, production equipment and labor to the relevant period of time. the total of all production operations over the same time period:

$$\boldsymbol{b_0} = 1 - \left(\frac{\sum_{i=1}^{m} M_i + \sum_{j=1}^{n} N_j}{\sum_{k=1}^{p} P_k} \right), \tag{4.9}$$

where $\sum_{i=1}^{m} M_i$ - total number of occurrences of sources of hazardous production factors over a specified period of time;

$\sum_{j=1}^{n} N_j$ - total number of occurrences of harmful production factors during the same defined period of time;

$\sum_{k=1}^{p} P_k$ - total sum of all production operations over the same defined period of time.

Table 4.1

Student ____________________ Group __________ Variant __________

Basic safety indicators	Conclusions
The level of safety of the technological process **LS_I =**	
Safety level of production equipment **LS_{II} =**	
The level of safety of the work process **LS_{III} =**	
Overall level of safety of working conditions **$LS_{\sum}$ =**	
The overall level of risk of harmful and dangerous production factors **$LD_{\sum}$ =**	
Integral indicator of safety of working conditions **(b_0) =**	

Table 4.2

INITIAL DATA

Variant	$\sum_{i=1}^{n} t_i^I$	$\sum_{j=1}^{m} \tau_j^I$	$\sum_{k=1}^{p} \varphi_k^I$	T^I	$\sum_{i=1}^{n} t_i^{II}$	$\sum_{j=1}^{m} \tau_j^{II}$	T^{II}	$\sum_{i=1}^{n} t_i^{III}$	$\sum_{i=1}^{m} M_i$	$\sum_{j=1}^{n} N_j$	$\sum_{k=1}^{p} P_k$
	57,2	3,4	19,6	4700	31,6	2,7	4700	114,5	49	37	7320

TOPIC #5: METHODS OF ANALYSIS OF OCCUPATION INJURY AND OCCUPATION DISEASE

Purpose of this work: to obtain the necessary practical skills to apply existing methods of analysis of occupational injuries and occupational morbidity.

Statement

Analysis of occupational injuries makes it possible not only to identify the causes, but also to determine the patterns of their occurrence. Based on this information, injury prevention tools are being developed. Many different methods are used for the analysis of occupational injuries, the main ones being statistical, topographic, monographic, economic, questioning, ergonomic, psychophysiological, expert assessments and others.

Task

To evaluate levels of occupational injuries and occupational morbidity using the statistical method of analysis, according to the initial data, ***table 5.2***.

1. to determine accident frequency and severity ratio;
2. to determine production loss ratio;
3. to determine fatal accident ratio.

Report

1. student's first name, family name, group and variant using ***table 5.1***;
2. Accident Frequency Ratio: K_{af} = ... ;
3. Accident Severity Ratio: K_{as} = ... ;
4. Production Loss Ratio: K_{pl} = ... ;
5. Fatal Accident Ratio: K_{fa} = ...

The quantitative injury rate, or Accident Frequency Ratio (K_{af}), is calculated for 1,000 employees:

$$K_{af} = 1000 \cdot n/P, \tag{5.1}$$

where n - number of accidents during the reporting period with disability for one or more days;

P - average number of employees over the same reporting period.

The qualitative trauma rate, or Accident Severity Ratio (K_{as}), characterizes the average disability in days per victim in the reporting period:

$$K_{as} = D/n, \tag{5.2}$$

where D - total number of days of disability of victims for disability cases for one or more days.

A summary measure showing the number of man-days of disability per 1000 employees is the Production Loss Ratio (K_{pl}):

$$K_{pl} = K_{af}\,K_{as} = 1000 \cdot D/P. \quad (5.3)$$

However, none of these indicators takes into account the persistent disability and deaths and therefore cannot fully characterize the level of injury. You need to use at least one more metric. The following is the Fatal Accident Rate (K_{fa}):

$$K_{fa} = 100 \cdot n_{di} / n, \quad (5.4)$$

where n_{di} - number of accidents that led to death and injury;

n - the total number of accidents.

The International Labor Organization uses a frequency coefficient that shows the number of accidents per 1,000,000 man-hours (K_f^{ILO}).

$$K_f^{ILO} = 1\,000\,000 \cdot n/T, \quad (5.5)$$

where T - total working time during the year, man-hours.

These and other indicators allow you to study the dynamics of injury at the enterprise, industry, region, etc., to compare these indicators, to draw certain conclusions, to apply organizational measures aimed at injury prevention.

Table 5.1

Student ____________________ Group __________ Variant __________

Ratios	*Conclusions*
Accident Frequency Ratio K_{af} =	
Accident Severity Ratio K_{as} =	
Production Loss Ratio K_{pl} =	
Fatal Accident Ratio K_{fa} =	

Table 5.2

INITIAL DATA

Variant	n	P	D	n_{di}
1	7	210	62	0
2	16	110	162	1
3	31	1200	310	2
4	3	57	120	1
5	12	1570	320	2
6	3	150	12	0

TOPIC #6: 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**, ^{o}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 6.7.***

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 6.5***;
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 = ... ^{o}C***;
5. optimum and valid values of relative humidity: ***W = ... %;***
6. optimum and valid values of air velocity: ***V = ... 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 6.1.***

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 6.2*** and ***6.3.***

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.

Table 6.1

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 6.7.***

Report

1. student's first name, family name, group and variant using ***table 6.5***;
2. the values of the Threshold limit value (TLV) for harmful substances according to your variant and the specific features of the action: ***TLV = ... mg / m³*** ;
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 6.4*. 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:

$$C_1 / TLV_1 + C_2 / TLV_2 + \ldots + C_n / TLV_n \leq 1 \text{ are satisfied.} \qquad (6.1)$$

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 6.2

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 6.3

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 6.4

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

Table 6.5

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, °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, 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

Table 6.6

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 / m3	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 $C_1 / TLV_1 + C_2 / TLV_2 + \ldots + C_i / TLV_i =$)	Satisfies / does not meet the actual concentration standards (must be entered)

General conclusion	

Table 6.7

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

Table 6.8

INITIAL DATA FOR PART 2

Variant №	Fact. conc., mg/m3	Substance
1	0,5	Aluminum
	0,03	Nickel
	0,8	Asbestos dust
	5	Dust of cement
2	1	Aluminum
	1	Asbestos dust
	3	Dust of cement
	0,01	Plumbum
3	2	Aluminum
	0,06	Nickel
	1	Asbestos dust
	0,02	Plumbum
4	8	Ammonia
	80	Gasoline
	6	Dust of cement
	4,5	Methyl alcohol
5	21	Ammonia
	100	Acetone
	5	Methyl alcohol
	0,4	Phenol
6	20	Ammonia
	4	Asbestos dust
	6	Dust of cement
	0,2	Phenol
7	5	Ammonia
	230	Acetone
	25	Gasoline
	2	Methyl alcohol
8	60	Acetone
	50	Gasoline
	1,5	Methyl alcohol
	0,5	Phenol
9	7	Ammonia
	140	Acetone
	2	Dust of cement
	3	Methyl alcohol
10	150	Acetone
	65	Gasoline
	3	Asbestos dust
	6	Dust of cement

Variant №	Fact. conc., mg/m3	Substance
11	2,1	Aluminum
	0,06	Nickel
	1,1	Asbestos dust
	5	Dust of cement
12	2	Aluminum
	1	Asbestos dust
	5	Dust of cement
	0,02	Plumbum
13	1,8	Aluminum
	0,07	Nickel
	1,5	Asbestos dust
	0,01	Plumbum
14	19	Ammonia
	95	Gasoline
	5	Dust of cement
	5	Methyl alcohol
15	13	Ammonia
	167	Acetone
	4	Methyl alcohol
	0,4	Phenol
16	18	Ammonia
	3	Asbestos dust
	5	Dust of cement
	0,5	Phenol
17	17	Ammonia
	201	Acetone
	74	Gasoline
	6	Methyl alcohol
18	195	Acetone
	10	Gasoline
	4	Methyl alcohol
	0,3	Phenol
19	18	Ammonia
	78	Acetone
	5	Dust of cement
	5,5	Methyl alcohol
20	190	Acetone
	81	Gasoline
	1	Asbestos dust
	3	Dust of cement

Variant №	Fact. conc., mg/m3	Substance
21	2	Aluminum
	0,1	Nickel
	0,3	Asbestos dust
	1	Dust of cement
22	4	Aluminum
	0,5	Asbestos dust
	3	Dust of cement
	0,03	Plumbum
23	4	Aluminum
	0,2	Nickel
	0,5	Asbestos dust
	0,04	Plumbum
24	15	Ammonia
	60	Gasoline
	4	Dust of cement
	7	Methyl alcohol
25	3	Ammonia
	200	Acetone
	6	Methyl alcohol
	0,5	Phenol
26	10	Ammonia
	2	Asbestos dust
	2	Dust of cement
	0,15	Phenol
27	10	Ammonia
	20	Acetone
	10	Gasoline
	4,5	Methyl alcohol
28	40	Acetone
	87	Gasoline
	3,5	Methyl alcohol
	0,1	Phenol
29	4	Ammonia
	90	Acetone
	3	Dust of cement
	6	Methyl alcohol
30	100	Acetone
	25	Gasoline
	2	Asbestos dust
	4	Dust of cement

TOPIC #7: 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 7.5.***

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 7.4***;
2. external heat inflow: $\boldsymbol{Q_e = \ldots W}$;
3. release of heat from equipment: $\boldsymbol{Q_o = \ldots W}$;
4. heat output from the workers depending on the energy consuming: $\boldsymbol{Q_w = \ldots W}$;
5. desired power of the split air conditioner: $\boldsymbol{Qx = \ldots W}$;
6. amount of heat that is lost by a building: $\boldsymbol{Q_b = \ldots W}$;
7. relative water consumption per equivalent m^2: $\boldsymbol{q = \ldots kcal / h}$;
8. value of the equivalent m^2: $\boldsymbol{q_{em2} = \ldots kcal / h}$;
9. required surface of the devices equivalent: $\boldsymbol{F_d = \ldots m^2}$;
10. required number of radiator sections: $\boldsymbol{n_d = \ldots m^2}$.

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 $\mathbf{Q_e}$ use the formula:

$$\mathbf{Q_e} = \mathbf{q_o} \cdot \mathbf{V}, \tag{7.1}$$

where $\mathbf{q_o}$ = 40, for the South orientation, $\mathbf{q_o}$ = 30, for the North, the average value of $\mathbf{q_o}$ = 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:

$$\mathbf{V} = \mathbf{a} \cdot \mathbf{b} \cdot \mathbf{h}, \tag{7.2}$$

To calculate release of heat from equipment $\mathbf{Q_o}$ use the formula:

$$\mathbf{Q_o}=0{,}3\cdot\mathbf{P}+\mathbf{n_k}\cdot\mathbf{Q_{ok}}, \qquad (7.3)$$

where 0.3***P** - for electrical appliances, where **P** – rated power, *W*;

$\mathbf{n_k}$ – number of office equipment units;

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

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

$$\mathbf{Q_w}=\mathbf{n_w}\cdot\mathbf{Q_{ow}}, \qquad (7.4)$$

where $\mathbf{n_w}$ – number of employees;

$\mathbf{Q_{ow}}$ – 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:

$$\mathbf{Q_x}=\mathbf{Q_e}+\mathbf{Q_o}+\mathbf{Q_w}, \qquad (7.5)$$

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

$$\mathbf{Q_b}=\mathbf{k}\cdot F_c\cdot(t_{in}-t_{out}), \qquad (7.6)$$

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 kcal/h $\cdot$ m^2 $\cdot$ °C;

$\mathbf{t}_{in}$ – the normalized room temperature, °C (***table 7.3***);

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

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

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

$$\mathbf{Fc}=\mathbf{a}\cdot\mathbf{h}. \qquad (7.7)$$

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:

$$q=\frac{7.98(\Delta t-10)}{\Delta T_{\text{device}}\cdot L}, \qquad (7.8)$$

where **Δt** – the temperature difference between the average temperature of the heat carrier in the heating device and the room temperature, °C:

$$\Delta t = \frac{t_{st} + t_{end}}{2} - t_{in}, \qquad (7.9)$$

$\mathbf{\Delta T_{device}}$ – temperature difference of the heat carrier in the heating device, °C.

$$\Delta T_{\text{device}} = t_{st} - t_{end}, \qquad (7.10)$$

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

$$\mathbf{q_{e.m2}} = 7{,}98(\mathbf{\Delta t} - 10) \cdot \boldsymbol{\alpha}, \qquad (7.11)$$

where $\boldsymbol{\alpha}$ – the correction coefficient that depends on the relative water consumption (***table 7.1***).

Table 7.1

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 **α** =0.92.*

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

$$\mathbf{F_d} = \frac{\mathbf{Q_k}}{\mathbf{q_{екм}}}. \qquad (7.12)$$

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

$$\mathbf{n_d} = \frac{\mathbf{F_{пр}}}{\mathbf{f_{екм}}}, \qquad (7.13)$$

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

Table 7.2

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 7.3

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,** ^oC	**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

Table 7.4

Student ____________________ Group __________ Variant __________

Choice of a "split" air conditioner

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

Required number of radiator sections

$Q_b = k \bullet F_c(t_{in} - t_{out}) =$	=	
$.F_C = a \times h =$	=	
$q = \frac{7.98(\Delta t - 10)}{\Delta T_{\text{device}} \cdot L}$	=	
$\Delta t = \frac{t_{st} + t_{end}}{2} - t_{in} =$	=	
$\Delta T_{\text{device}} = t_{st} - t_{end} =$	=	
$\mathbf{q_{e.m2}} = 7{,}98(\mathbf{\Delta t} - 10) \cdot \boldsymbol{\alpha} =$	=	
$\mathbf{F_{пр}} = \frac{\mathbf{Q_k}}{\mathbf{q_{екм}}} =$	=	
$\mathbf{n_{пр}} = \frac{\mathbf{F_{пр}}}{\mathbf{f_{екм}}} =$	=	

Table 7.5

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
		a	*b*	*h*					
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 #8: 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 $\mathbf{s_o}$ 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 ρ_c = 70%, the walls are light gray ρ_w = 50%, the floor of oak ρ_f = 30%. The height of the working surface $\mathbf{h_w}$ is 0.8m.

Task

To evaluate lighting system at the room, according to the initial data, ***table 8.5***.

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 8.4***;
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 **= ... *lx*** ;
4. the actual illumination in the room: E_a **= ... *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. 8.1***).

Then using same ***table 8.1*** 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. 8.2***. Then calculate the room index **i** according to the formula:

$$i = a \cdot b / (h_c \cdot (a + b)), \quad (8.1)$$

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. 8.3);

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

Calculate value of the actual illumination using the formula:

$$Ea = F_l \cdot N \cdot n \cdot \eta / (S \cdot k \cdot z), \quad (8.2)$$

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, m^2,

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 8.1

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	а	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 Big	Bright Average Dark	2500 2000	300 200	750 600	20 10	10 10				
			г	Average Big Big	Bright Bright Average	1500 1250	200 200	400 300	20 10	10 10				
Very high accuracy	From 0.15 to 0.3	II	а	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 Big	Bright Average Dark	2000 1500	200 200	500 400	20 10	10 10				
			г	Average Big Big	Bright Bright Average	1000 750	200 200	300 200	20 10	10 10				

Table 8.1 (cont.)

High accuracy	From 0.3 to 0.5	III	а	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	а	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	а	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 8.1 (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	а	—	–	–	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 8.2

Specifications of low pressure fluorescent lamps

Lamp type	Powe, 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 8.3

The light flux coefficient

ρc	0.7	0.7	0.5	0.5	0
ρw	0.5	0.5	0.5	0.3	0
ρf	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

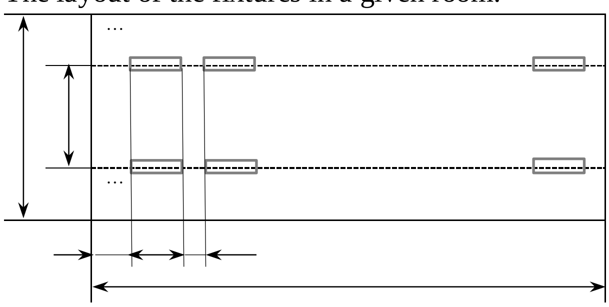
Table 8.4

Student ____________________ Group __________ Variant __________

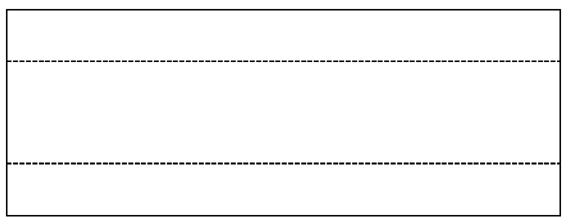
Output data:	
The length of the room **a**, m	
The width of the room **b**, m	
Room height **h**, m	
Working surfaces height $\mathbf{h_w}$, m	
The minimum size of the distinguished object $\mathbf{s_o}$, mm	
Background characteristic	
Contrast between the object and the background	
Ceiling reflection coefficient $\boldsymbol{\rho_c}$	
Wall reflection coefficient $\boldsymbol{\rho_w}$	
Floor reflection coefficient $\boldsymbol{\rho_f}$	
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 $\mathbf{E_n}$, lx.	
3.1. the luminous flux emitted by each of the lamps, $\mathbf{F_l}$, lm (table 5.2)	
lamp length, mm *	
3.2. the room index **i** according to the formula $\mathbf{i} = \mathbf{a} \cdot \mathbf{b} / (\mathbf{h_c} \cdot (\mathbf{a} + \mathbf{b})) =$	
The distance between working place and ceiling $\mathbf{h_c} = \mathbf{h} - \mathbf{h_w}$	
3.3. luminous flux coefficient $\boldsymbol{\eta}$ (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 $\mathbf{N_p}$ 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

Table 8.5

INITIAL DATA FOR THE INDUSTRIAL LIGHTING EVALUATION

Variant	Room paremeters, m			Characteristic of visual work			Quantity of lamps, **N**, 40 Вт	lamp type
	a	***h***	***b***	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)

TOPIC #9: ASSESSMENT OF PARAMETERS OF INDUSTRIAL LIGHTING, 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. 8.1***). 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 9.3***.

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 9.2***;
2. normalized Natural Light Ratio for the premises specified in the conditions: $e_n =$ **...**;
3. the value of the actual Natural Light Ratio at each point at which the value of natural light was measured: $e_a =$ **...**;
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 $\mathbf{e_n}$ use Table 8.1 for day lighting system based on the category and subcategory of visual work.

Determine the coefficient of light climate m_N due to Table 9.1 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

$$e_N = e_n \cdot m_N, \tag{9.1}$$

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

$$\mathbf{e_a} = (\boldsymbol{E}_{\mathbf{in}} / \boldsymbol{E}_{\mathbf{out}}), \tag{9.2}$$

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 9.1

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

Table 9.2

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:

п.1. 1. $\mathbf{e_n}$ = for ____ illumination

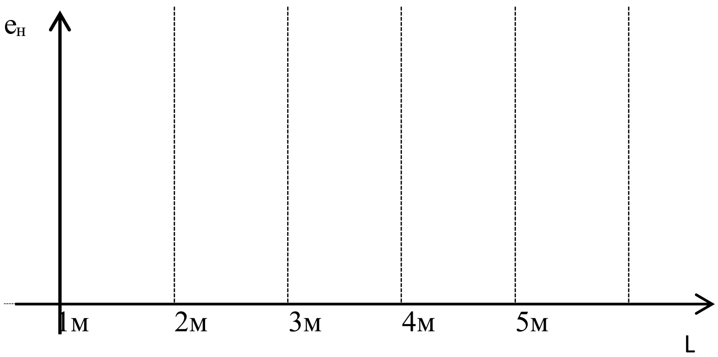
п. 1.2. m_N=

п. 1.3. $e_N = e_н\, m_N$ =

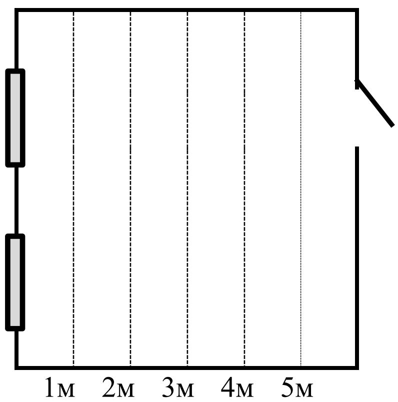
п. 2. $e_a = (E_{in}\ / E_{out})\ 100\%$

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):

Table 9.3

INITIAL DATA FOR THE NATURAL LIGHTING EVALUATION

Variant	Magnitude of natural light $\mathbf{E_{in}}$, lx, on the distance **L**, m, from the window					Orientation of windows on the sides of the horizon	Exterior illumination $\mathbf{E_{out}}$, 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 #10: CALCULATING NOISE DEPENDING ON DISTANCE, LOCATIONS OF SOURCES AND DETERMINING TOTAL SOUND PRESSURE LEVEL

Purpose of this work: to obtain the necessary practical skills for the ability to estimate the noise and sound pressure level by calculation methods.

Statement

At the same time, the study workplace receives noises from four sources (1, 2, 3, 4), the characteristics of which are provided by the teacher.

Task

To estimate the noise and sound pressure level at the study workplace, according to the initial data, ***table 10.3***.

1. to determine the sound pressure level at the workplace from separate sources;
2. to determine the total sound power level of all groups of noise sources;
3. to determine the average sound pressure level.

Report

1. student’s first name, family name, group and variant using table 10.2;
2. determine the sound pressure level at the workplace from 4 separate sources: Lrn = ... dBA;
3. determine the total sound power level of all groups of noise sources for a calculation point in two ways: Lsum = ... dBA;
4. determine the average level for which the sum "n" is subtracted from 10 lg(n): LAaver = ... dBA;

To determine the sound pressure level at the workplace complete all the necessary calculations using the formulas:

$$\mathbf{L_{r1}} = \mathbf{L_1} - 10 \lg (1/2\pi\, \mathbf{r_1}^2), \quad (10.1)$$

$$\mathbf{L_{r2}} = \mathbf{L_2} - 10 \lg (2\pi\, \mathbf{r_2}^2), \quad (10.2)$$

$$\mathbf{L_{r3,4}} = \mathbf{L_{3,4}} - 10 \lg (\pi\, \mathbf{r_{3,4}}^2), \quad (10.3)$$

where $\boldsymbol{r_i}$ - distance from the noise source to the ear of the employee according to the layout plan (Fig. 10.1);

$\boldsymbol{L_i}$ - is the power level of an individual noise source.

Note. In fact, a decrease in level is not only related to its distance from the source. Other factors are also affected, such as sound absorption by the floor surface, obstacles encountered, and others. However, the impact of such factors is difficult to account for in the metric form. The above levels only take into account the geometric component - the distance from the noise source. In the actual installation of the equipment in the room, or near the reflecting surfaces, it is necessary to enter the appropriate factors that take into account the acoustic characteristics of the room and the reflection of sound from *the walls of the room. All of this leads to the fact that the sound pressure level of the installed equipment will be much higher than the values measured in the laboratory and listed in the equipment catalogs. For example, the pressure reduction can be only 3-4 dB.*

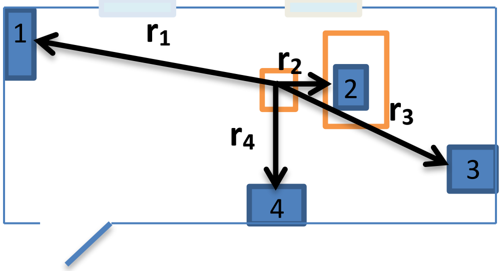


Fig. 10.1. Plan of the room, where 1, 2, 3, 4 are noise sources; r_1, r_2, r_3, r_4 are distances to noise sources.

Determine the total sound power level of all groups of noise sources in two ways:

- using the formula $L_{sum} = 10\ lg\ (10^{0,1L_1} + 10^{0,1L_2} + 10^{0,1L_3} + 10^{0,1L_4});$

- by means of a nomogram to calculate the sum of the levels of sound intensity or sound pressure (Tab. 7.1) through pairwise sequential addition of levels from the highest to the lowest level.

Table 10.1

Nomogram for determining the average noise level LA_{aver}, dBA or octave sound pressure levels L_{aver}, dB

The difference between the two levels being added is dBA or dB	0	1	2	3	4	5	6	7	8	9	10	15	20
Addition to higher level, dB	3,0	2,5	2,0	1,8	1,5	1,2	1,0	0,8	0,6	0,5	0,4	0,2	0

Adding levels by nomogram is carried out in the following order:

1) choose the pair of the largest values of levels and subtract the smaller ones, that is, find the difference of the two largest levels;

2) in accordance with the obtained difference from table 1 define the application that is added to the greater of the pair of levels;

3) subtract from the amount received the third largest level, find the difference and add the appropriate addition to the amount

4) similar actions are performed with all levels sequentially from bigger to smaller.

Note. If the difference between the levels is greater than or equal to 20 dBA, then all smaller values are discarded because the application is 0 (see table 1).

Determine the average level for which the sum "**n**" is subtracted from 10 lg (**n**).

If the difference between the highest and lowest measured levels does not exceed 5 dB, then the average value is $\mathbf{LA_{aver}}$. $\mathbf{L_{aver}}$ is equal to the arithmetic mean of all measured levels.

Table 10.2

Student ____________________ Group __________ Variant __________

1. The level of sound pressure at the workplace from separate sources

Formula	With substituted values	Result
$L_{r1} = L_1 - 10\ lg\ (1/2\pi\ r_1^{\ 2})=$		
$L_{r2} = L_2 - 10\ lg\ (2\pi\ r_2^{\ 2})=$		
$L_{r3} = L_3 - 10\ lg\ (\pi\ r_3^{\ 2})=$		
$L_{r4} = L_4 - 10\ lg\ (\pi\ r_4^{\ 2})=$		

2. Total sound power level of all groups of noise sources:
   - by the formula

$L_{sum}=10lg(10^{0,1Lr_1}+...+10^{0,1Lr_4})=$		

   - by the nomogram

$L_{larger} - L_{lower}$ = (specify value)	The difference of values $L_{larger} - L_{lower}$	ΔL_i

3. Average value $L_{sum}=10lg\ L_{sum}$ =

Table 10.3

INITIAL DATA FOR THE NOISE EVALUATION

Variant	Sound levels L_i, dBA coming to the workplace from each individual noise source and the corresponding distance r_i by the noise source number							
	1		2		3		4	
	L_1	r_1	L_2	r_2	L_3	r_3	L_4	r_4
1	70	6	50	0,5	65	4	73	2
2	68	5	63	1	65	5	70	4
3	80	7	65	0,8	60	3	75	3
4	78	8	60	0,9	67	2	70	4
5	76	4	55	0,7	68	6	73	4
6	74	6	50	0,5	70	4	75	2
7	83	5	63	1	72	5	80	4
8	85	7	65	0,8	75	3	85	3
9	85	8	60	0,9	80	2	80	4
10	83	4	55	0,7	80	6	65	4

TOPIC #11: ASSESSMENT OF THE REQUIRED LEVEL OF SAFETY OF CARS BY THE PARAMETERS OF RISK OF DANGEROUS SITUATIONS DURING THEIR EXPLOITATION

Purpose of this work: to obtain the necessary practical skills to be able to perform a preliminary assessment of the required level of safety of the designed machines and their control and control systems, depending on the risk parameters of dangerous situations that may occur during their exploitation.

Statement

Any production equipment, depending on the conditions of its exploitation, should ensure the performance of the relevant safety functions, as well as have adequate guarantees regarding the possibility of their provision according the existing requirements of European and Ukrainian legislation in the field of industrial and industrial safety

The main standards governing the safety requirements for machines and their control and monitoring systems are EN 954-1 (ДСТУ EN 954-1: 2003), EN ISO 13849-1 (ДСТУ EN ISO 13849-1-2016), IEC 62061 and EN ISO 12100 (ДСТУ EN ISO 12100: 2016).

Task

To evaluate safety of the designed machines and their control and control systems, depending on the risk parameters, according to the initial data, ***table 11.2***.

1. to determine Operational Safety Level;
2. to determine Hourly Dangerous Chance Probability;
3. to determine Level of completeness.

Report

1. student's first name, family name, group and variant using ***table 11.1;***
2. Operational Safety Level: ***PL* = ...** ;
3. Hourly Dangerous Chance Probability: ***PFHd* = ...** ;
4. Level of completeness: ***SIL* = ...** .

According to the initial data, determine the required level of operational safety **PL** (a, b, c, d, e) of production equipment according to **EN ISO 13849**.

*Notes: the operational safety level **PL** (a, b, c, d, e) is determined by the algorithm shown in **Fig. 11.2**.*

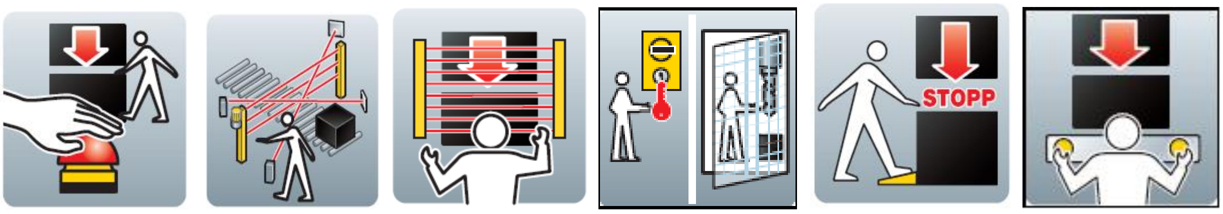
According to the results obtained from the previous task, determine the safety parameter of production equipment as the probability of dangerous failure per hour **PFHd** according to **EN ISO 1384**.

*Notes: hazardous failure rate per hour (**PFHd**) is determined by the algorithm shown in diagram in **Fig. 14.3**.*

According to the results obtained from the previous task determine the safety parameter of production equipment as the level of complete safety **SIL** according to **IEC 62061**.

*Notes: When determining the level of completeness of safety (**SIL**) according to **IEC 62061**, use the diagram in **Fig. 11.4.***

The main security features include:



- shutdown of the equipment in case of an emergency;
- blocking of protective barriers / fences /;
- protection against restart of the equipment in case of power failure;
- creation of protective light barriers;
- two-position (two-hand) control, etc.

Existing safety categories according to **EN 954-1** «Safety of Machinery - Safety Related Parts of Control Systems»:

B - (Protection / Control Systems and Components)

1 - In addition to "B" (Tested Components and Principles for Safety).

2 - In addition to "B" (Checking the safety features of the control system at the intervals / testing and diagnostics /).

3 - In addition to "B" (fault tolerance and fault detection at the appropriate technical level).

4 - In addition to "B" (fault tolerance and fault detection as well as no risk of accumulation of faults).

Note: when classifying indicators of equipment safety features, a parameter of the security category is used.

In **EN ISO 13849-1/-2** «Safety of machinery - Safety-related parts of control systems» - five values of PL (a, b, c, d, e,), which are determined by the average PFHd, are used to classify performance indicators for the operation of the equipment. Level "a": the contribution of management functions to reducing risk is the lowest, and at the level of PL "e" - the highest

Notes: unlike EN 954-1, which uses a deterministic (qualitative) approach, EN ISO 13849-1 applies a probabilistic approach that allows quantitative consideration of the safety features.

The final verification of all protective measures that ensure the proper performance of the intended safety functions is a mandatory part of EN ISO 13849-2.

In **IEC 62061** «Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems» the safety level of equipment is determined by three levels of the so-called SIL - Safety Integrity (1, 2, 3).

It should be noted that the application of any precautionary measures used to eliminate existing hazards and reduce the levels of potential risks should be carried out in a consistent manner in accordance with the requirements of **EN ISO 12100-1**, which is illustrated in ***Fig. 11.1***.

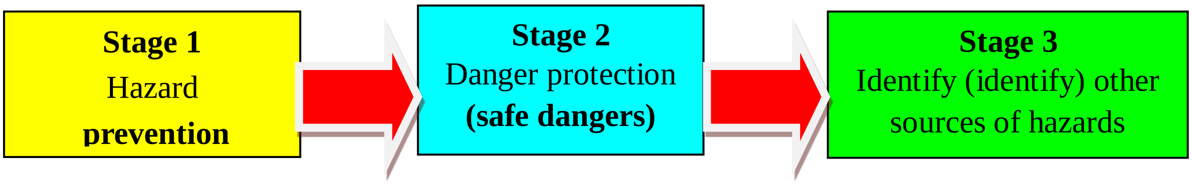


Fig. 11.1. The sequence of implementation of protective measures according to EN ISO 12100-1

Stage 1 Hazard prevention: eliminating existing hazards and reducing levels of potential risks through appropriate design measures at the design and development stages of the machine.

Stage 2. Hazard protection: Reduce the level of potential risks by introducing the necessary protective measures.

Stage 3. Identifying (identifying) other sources of hazards: Reducing the levels of potential risks by providing additional information / warnings / residual risks.

If the final result of stage 1 "Prevention of Dangers" does not sufficiently reduce the levels of potential risks in accordance with the requirements of **EN ISO 12100-1**, then the iterative design process in accordance with the requirements of **ISO 13849-1** or **IEC 62061** should also be used in phase 2 - "Safe Dangers".

Those parts of the machinery management systems that meet the safety objectives are defined in international standards as "safety-related parts of control systems" (SRP / SS). In accordance with the requirements of both standards (**ISO 13849-1** and **IEC 62061**), the necessary security features must be provided by SRP / CS.

The algorithm for determining the required level of operational safety PL (a, b, c, d, e) according to **EN ISO 13849** is shown in **Fig. 11.2**.

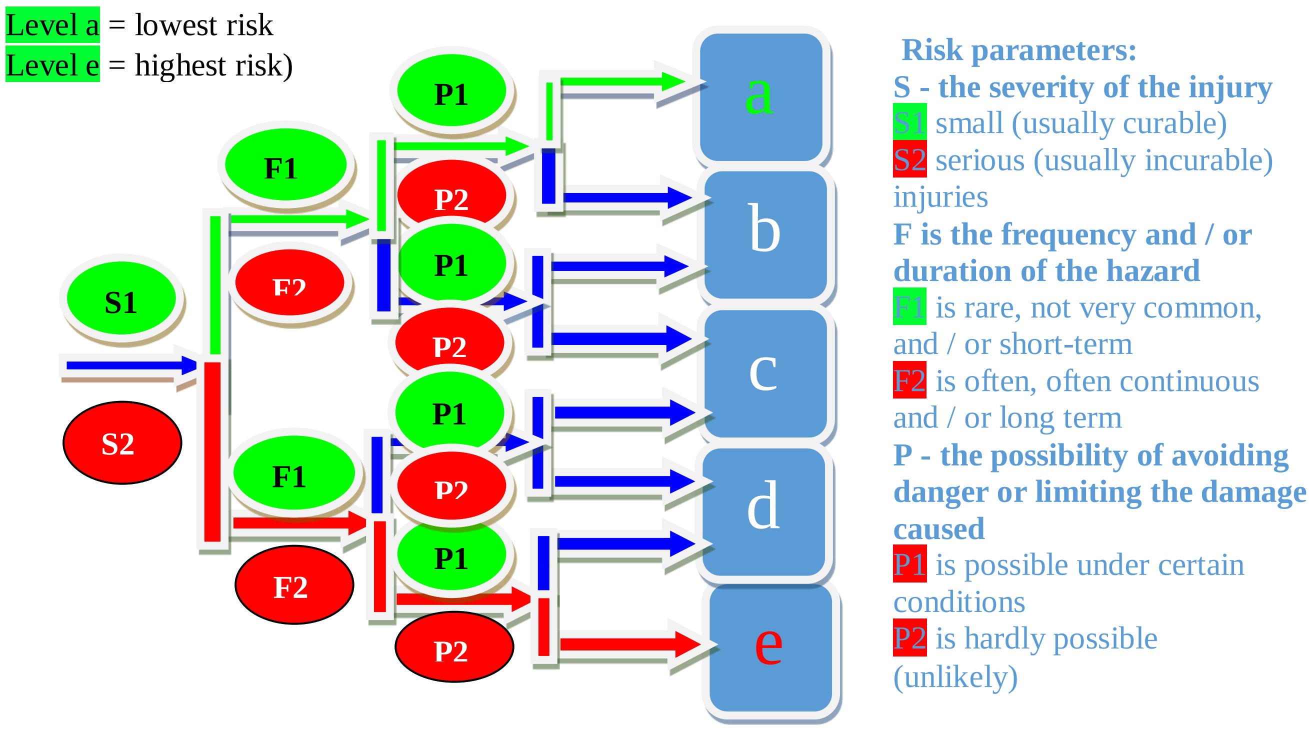


Fig. 11.2. An algorithm for determining the required level of operational safety PL (a, b, c, d, e) according to EN ISO 13849

Figure 11.3 shows the relationship between the hazardous failure rate per hour (PFHd) and the operational safety level of PL (**EN ISO 13849**).

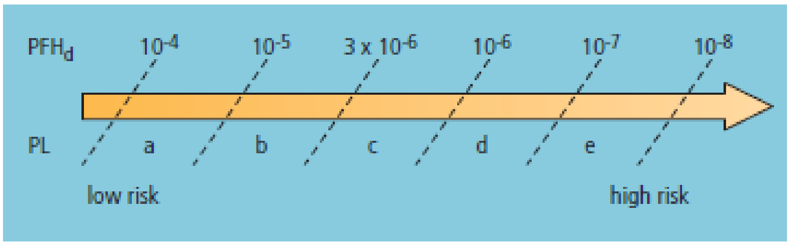


Fig. 11.3. Hourly Hazardous Breakdown Probability Relationship (PFHd) and operational safety level PL – EN ISO 13849

The relationship between the hazardous failure rate per hour (PFHd) and the level of completeness of the SIL (**IEC 62061**) is shown in **Fig. 11.4**.

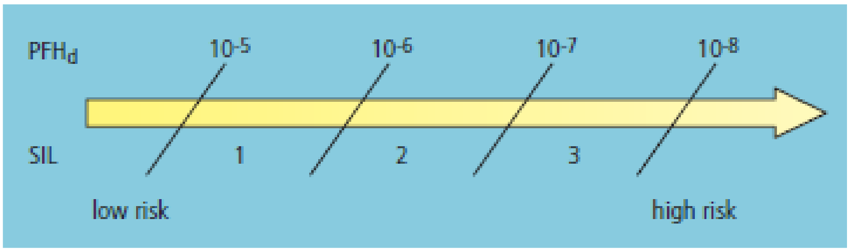


Fig. 11.4. The relationship between the hazardous failure rate per hour (PFHd) and the level of completeness of the SIL

Table 11.1

Student ____________________ Group __________ Variant __________

Variant	***Operational Safety Level (PL)*** /EN ISO 13849/	***Hourly Dangerous Chance Probability (PFHd)*** /EN ISO 1384/	***Level of completeness (SIL)*** /IEC 62061/

Table 11.2

INITIAL DATA

	Risk parameters		
Variant	**S - severity of injury**	**F - frequency of exposure**	**P - avoidance of danger**
1	minor	rarely, not very often	unlikely
2	minor	short-term action	possible under certain conditions
3	serious	rarely, not very often	hardly possible (unlikely)

TOPIC #12: 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 12.6.***

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 12.5***;
2. electrical resistance of the shoes: rs = ... Ω ;
3. electrical resistance of the support surface of the feet on the floor: rf = ... Ω ;
4. electrical resistance of human circuit: rh = ... Ω ;
5. current that will flow through the person: Ih = ... A ;
6. voltage applied to the person: Uh = ... 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 15.1***), since these resistances are connected in parallel:

$$r_s = r'_s / 2. \tag{12.1}$$

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 15.2***.

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:

$$r_f = 0{,}022 \cdot \rho, \tag{12.2}$$

where ρ - soil resistivity according to the ***table 12.3***, $\Omega \cdot m$.

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:

$$r_h = r_l + r_s + r_f, \tag{12.3}$$

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

$$I_h^{11} = \frac{U_p}{r_h + \frac{r}{3}}; \tag{12.4}$$

2. single phase emergency mode touch with isolated transformer neutral

$$I_h^{12} = \frac{U_p}{r_h + R_p}; \tag{12.5}$$

3. two-phase touch with isolated transformer neutral

$$I_h^{13} = \frac{U_l}{r_l}; \tag{12.6}$$

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

$$I_h^{21} = \frac{U_p}{r_h + R_p}; \tag{12.7}$$

5. single phase emergency mode touch with grounded transformer neutral

$$I_h^{22} = U_p \frac{R_g + \sqrt{3}R_p}{R_g R_p + r_h(R_g + R_p)}; \tag{12.8}$$

6. two-phase touch with grounded transformer neutral

$$I_h^{23} = \frac{U_l}{r_l}; \tag{12.9}$$

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

$$U_h = I_h \cdot r_l. \tag{12.9}$$

Using the ***tables 12.4-6*** show the possible result of the action of such current and voltage on the person.

Table 12.1

Electrical resistance of the shoes

Shoe sole	Humidity	Resistance, *кΩ*, 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 12.2

Electrical resistance of the support surface of the feet

Floor material	**Resistance, *κΩ***			**Floor material**	**Resistance, *κΩ*,**		
	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 12.3

Soil electrical resistivity

Soil	**Electrical resistivity, *Ω · m*,**		**Recommended for grounding calculations, *Ω · 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 12.4

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

Table 12.5

Student _____________________ Group __________ Variant __________

Var.	**U_l, V**	**r, кΩ**	**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 12.1***):

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

2. Electrical resistance of the support surface:

$$r_f =$$

3. Electrical resistance of the human circuit:

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

<table>
<tr><th>Neutral mode</th><th colspan="2">Type of Touch</th><th>Current, мA</th><th>Voltage, V</th><th>The type of the currents effect</th></tr>
<tr><td rowspan="3">Isolated</td><td colspan="2">single phase touch in normal mode</td><td>$I_h^{11} = \frac{U_p}{r_h + \frac{r}{3}} =$</td><td></td><td></td></tr>
<tr><td colspan="2">single phase emergency mode touch</td><td>$I_h^{12} = \frac{U_p}{r_h + R_g} =$</td><td></td><td></td></tr>
<tr><td colspan="2">two-phase touch</td><td>$I_h^{13} = \frac{U_l}{r_l} =$</td><td></td><td></td></tr>
<tr><td rowspan="4">Grounded</td><td colspan="2">single phase touch in normal mode</td><td>$I_h^{21} = \frac{U_p}{r_h + R_p} =$</td><td></td><td></td></tr>
<tr><td rowspan="2">single phase emergency mode touch</td><td>Exact formula</td><td>$I_h^{22} = U_p \frac{R_g + \sqrt{3}R_g}{R_п R_p + r_h(R_п + R_p)} =$</td><td></td><td></td></tr>
<tr><td>Approximate formula</td><td>$I_h^{22б} = \frac{U_p}{r_h} =$</td><td></td><td></td></tr>
<tr><td colspan="2">two-phase touch</td><td>$I_h^{23} = \frac{U_l}{r_l} =$</td><td></td><td></td></tr>
</table>

Table 12.6

INITIAL DATA

Variant	U_l, V	r, кΩ	R_p, Ω	R_g, Ω	r_l, 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 #13: ENSURING COMPLIANCE OF INDUSTRIAL FREQUENCY ELECTRIC FIELD INTENSITY IN WORKPLACES WITH SANITARY STANDARDS

Purpose of this work: to learn the principles of normalization and control of industrial frequency levels of the industrial frequency in workplaces and to make a conclusion about the compliance of working conditions with the existing sanitary standards.

Statement

Electric field of intensity $\mathbf{E_n}$ affects production personnel in the workplace

Task

To evaluate influence of electric intensity at workplace, according to the initial data, ***tables 13.3-5.***

1. to determine the permissible running time production personnel if they are under the influence of an electric field that has intensity;
2. to determine the maximum permissible values of the electric intensity of the industrial frequency in the controlled area at a given regulated time of stay of production personnel in this zone;
3. to determine the total reduced working time of production personnel in the case of their stay during the working day in 6 controlled zones with different electric intensity of industrial frequency.

Report

1. student's first name, family name, group and variant;
2. the permissible running time production personnel if they are under the influence of an electric intensity: T_{pN} **= ... *h*** ;
3. the maximum permissible values of the electric intensity E_l of the industrial frequency in the controlled area at a given regulated time of stay of production personnel in this zone: E_l **= ... *kV/m*** ;
4. the total reduced working time of production personnel in the case of their stay during the working day in 6 controlled zones with different electric intensity of industrial frequency: ***Tgiv* = ... *h*** .

According to existing standards, the threshold limit value (**TLV**) of an electric field of industrial frequency (intensity (**E**) of an electric field) depends on the time of action of this factor on the human body during the working day.

For example, being in an electric frequency of industrial frequency up to 5 kV/m inclusive is allowed within an 8-hour working day.

At levels of intensity of the electric field of industrial frequency from 5 to 20 kV / m inclusive, the allowable residence time in it is determined by the formula:

$$\mathbf{Tp} = 50 / \mathbf{E} - 2, \tag{13.1}$$

where **Tp -** permissible residence time in an electric field of industrial frequency at a given level of electric field strength (**E**) in the controlled area, *h*;

E - electric field intensity of the industrial frequency in the controlled area, *kV / m.*

** Note: The calculation according to this formula is allowed within 0.5 to 8 hours.*

If the electric field strength of the industrial frequency is from 20 to 25 kV / m, the time of stay of the personnel in the controlled area should not exceed 10 minutes.

It is forbidden to stay in an electric field of industrial frequency with a voltage greater than 25 kV / m without the use of protective equipment.

Hygienic standards for maximum permissible values of electric field strength at workplaces of personnel, which, under working conditions, are systematically (within each working day) stay within the range of the electric frequency of industrial frequency, are given in ***table 13.1.***

Table 13.1

The maximum field intensity of the industrial frequency and the allowable exposure time

Industrial frequency electric field intensity, kV / m	**Permissible time of stay of the person in an electric field of industrial frequency for one day, min.**
Less than 5	Without restriction
5 to 10	Not more than 180
More than 10 to 15	Not more than 90
Over 15 to 20	Not more than 30
Over 20 to 25	Not more than 10

If necessary, the following formula can be used to determine the TLV of the electric frequency of the industrial frequency at the workplace at a given time of stay of production personnel in the controlled area:

$$\mathbf{E_l} = \frac{50}{\mathbf{t} + 2}, \qquad (13.2)$$

where $\mathbf{E_l}$ - limit value of the electric field intensity of industrial frequency during the working day, *kV / m*;

t - regulated operating time in the electric field intensity of industrial frequency, *h*.

** Note: The calculation according to this formula is allowed within 0.5 to 8 hours.*

When the production personnel stay during the working day in zones with different intensity of the electric field of industrial frequency, the total reduced operating time must be determined by the following formula:

$$\mathbf{T_{giv}} = 8\left(\frac{\mathbf{t_{E_1}}}{\mathbf{T_{E_1}}} + \frac{\mathbf{t_{E_2}}}{\mathbf{T_{E_2}}} + \ldots + \frac{\mathbf{t_{E_n}}}{\mathbf{T_{E_n}}}\right), \qquad (13.3)$$

where $\mathbf{T_{giv}}$ - the time equivalent to the biological effect of being in the electric field of the industrial frequency of the lower limit of the normalized voltage, *hours*;

$\mathbf{t_{E1}}$, $\mathbf{t_{E2}}$...$\mathbf{t_{En}}$- time of stay in the controlled zones with the electric field intensity of industrial frequency according to $\mathbf{E_1}$, $\mathbf{E_2}$ ... $\mathbf{E_n}$, *hours*;

$\mathbf{T_{E1}}$,$\mathbf{T_{E2}}$...$\mathbf{T_{En}}$ - the permissible residence time in an industrial frequency electric field for the respective controlled zones, *hours*.

**Notes: The number of controlled zones is determined by the difference in the electric field strengths of the industrial frequency at the workplace. The divergence in the electric field intensity levels in the controlled areas shall be at least 1 kV / m.*

Student ____________________ Group __________ Variant __________

Table 13.3

The permissible working time of production personnel (T_{pN})

№	E_n	T_{pN}	№	E_n	T_{pN}
1	2	3	4	5	6
1	E_1 = 3 kV/m	T_{p1} (h) =	**7**	E_7 = 19 kV/m	T_{p7}(h) =
2	E_2 = 5 kV/m	T_{p2} (h) =	**8**	E_8 = 21 kV/m	T_{p8} (h) =
3	E_3 = 7 kV/m	T_{p3} (h) =	**9**	E_9 = 23 kV/m	T_{p9} (h) =
4	E_4 = 12 kV/m	T_{p4} (h) =	**10**	E_{10} = 25 kV/m	T_{p10} (h) =
5	E_5 = 14 kV/m	T_{p5} (h) =	**11**	E_{11} = 30 kV/m	T_{p11} (h) =
6	E_6 = 17 kV/m	T_{p6} (h) =	**12**	E_{12} = 110 kV/m	T_{p12} (h) =

Note: If the work at a given electric field strength is allowed only with the use of personal protective equipment, then in the appropriate boxes should be put* *T_{pN} (h) =0 (PPE)***

Table 13.4

Limit values of the electric intensity of the industrial frequency in the controlled area E_l at a regulated time of stay of production personnel in this zone.

№	t_w	E_{ln}	№	t_w	E_{ln}
1	t_{w1} (min) = 30	E_{l2}(kV/m) =	**7**	t_{w7} (h) = 4,7	E_{l8}(kV/m) =
2	t_{w2} (min) = 60	E_{l3}(kV/m) =	**8**	t_{w8} (h) = 5	E_{l9}(kV/m) =
3	t_{w3} (min) = 90	E_{l4}(kV/m) =	**9**	t_{w9} (h) = 5,3	E_{l10}(kV/m) =
4	t_{w4} (min) = 2	E_{l5}(kV/m) =	**10**	t_{w10} (h) = 6	E_{l11}(kV/m) =
5	t_{w5} (min) = 2,6	E_{l6}(kV/m) =	**11**	t_{w11} (h) = 7	E_{l12}(kV/m) =
6	t_{w6} (min) = 4	E_{l7}(kV/m) =	**12**	t_{w12} (h) = 8	E_{l12}(kV/m) =

**Note: If the values of the electric field strength require the use of personal protective equipment, then an additional mark should be made in the appropriate columns.*

Table 13.5

The working time of production personnel (T_{giv}) in the case of its stay during the working day in 6 controlled zones with different electric field intensity of industrial frequency (E_N).

№ зони	t_{EN}	E_N	T_{giv}
1	t_{E1} (min) = 90	E_1 (kV/m) = 7	T_{giv}(h) =
2	t_{E2} (min) = 45	E_2 (kV/m) = 12	
3	t_{E3} (min) = 60	E_3 (kV/m) = 14	
4	t_{E4} (min) = 90	E_4 (kV/m) = 17	
5	t_{E5} (min) = 60	E_5 (kV/m) = 19	
6	t_{E6} (min) = 30	E_6 (kV/m) = 23	

**Note: To conclude on the compliance of working conditions with the existing sanitary standards.*

TOPIC #14: CHOOSING THE TYPE OF FIRE EXTINGUISHERS AND DETERMINING THEIR QUANTITY AND CAPACITY TO ENSURE THE REQUIRED LEVEL OF FIRE SAFETY OF PRODUCTION FACILITIES PARAMETERS

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 14.3***.

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 14.4***;
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.В.1.1.- 36:2016 the premises for explosive and fire danger are divided into five categories (А, 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 А (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 А 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 m^2.

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 А, 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.

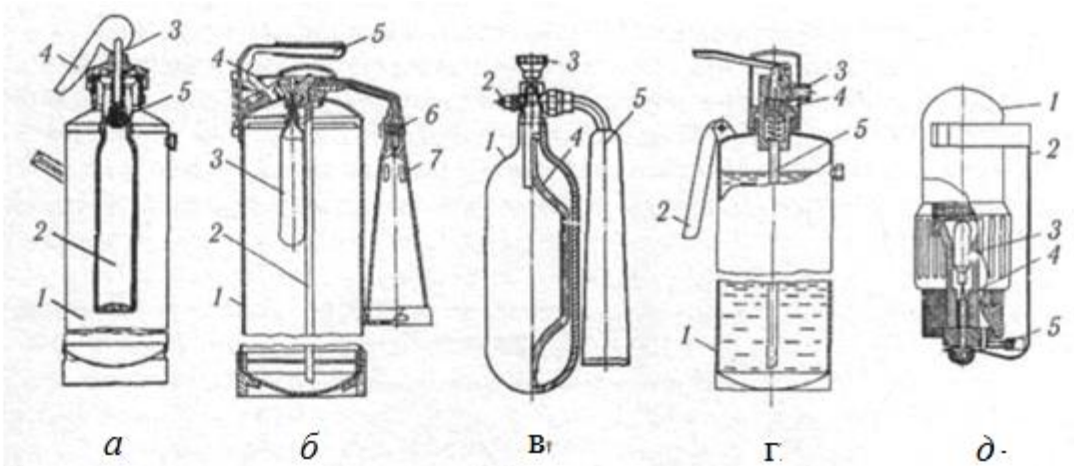


Fig. 14.1. Portable fire extinguishers:
а - fire extinguisher chemical foam ВХП-10: 1 - frame; 2 - glass; 3 - locking device; 4 – starting lever; 5 - shut-off valve;
б - fire extinguisher air-foam ВПП-10: 1 - frame; 2 - siphon tube; 3 - balloon; 4 - starting lever; 5 - handle; 6 - spray; 7 - diffuser with mesh;
в - carbon dioxide extinguisher ВВ-2: 1 - balloon; 2 - safety valve; 3 - the valve; 4 - siphon tube; 5 - diffuser-snowmaker;
г - carbon dioxide-bromethyl fire extinguisher ВВБ-3А: 1 - cylinder; 2 - handle; 3 - spray nozzle; 4 - cap; 5 - siphon tube;
д - powder fire extinguisher ВП-1 "Moment": 1 - frame; 2 - safety bracket; 3 - a can of carbon dioxide; 4 - needle; 5 - spray with plastic cap.

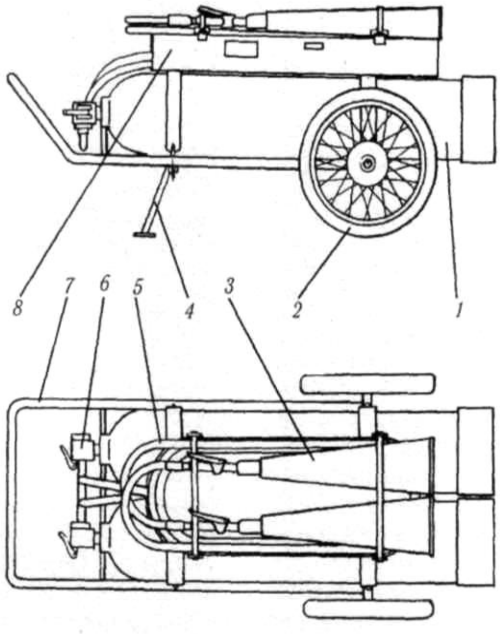


Fig. 14.2. Mobile ВВ-80 extinguisher:

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 і 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: ВВ-2, ВВ-5 and ВВ-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 ВВБ-3 and ВВБ-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 14.1) and (table 14.2) 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 14.1

Recommendations for the installation of portable fire extinguishers									
Room category	The maximum protected area, m^2	Fire class	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)
А, Б, В (flammable gases and liquids)	200	A B C D (E)	2++ 4+ - - -	- - - - -	2+ 2+ 2+ 2+ 2+	1++ 1++ 1++ 1++ 1++	- 4+ 4+ - -	- - - - -	- - - - 2++
В (except combustible gases and liquids)	400	A D (E)	2++ - -	4+ - -	2++ 2+ 2++	1+ 1++ 1+	- - 2+	- - 4+	2+ - 2++
Г	800	B C	2+ -	- 4+	2++ 2++	1+ 1+	- -	- -	- -
Г, Д	1800	A D (E)	2++ - -	4+ - 2+	2++ 2+ 2++	1+ 1++ 1+	- - 2+	- - 4+	- - 2++
Public buildings and structures	800	A (E)	4++ -	8+ -	4++ 4++	2+ 2+	- 4+	- 4+	4+ 2++

Table 14.2

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
А, Б, В (combustible gases and liquids)	500	A B C D (E)	1++ 2+ - - -	1++ 1++ 1+ - -	1++ 1++ 1+ 1++ 1+	- - - - 2+	3+ 3+ 3+ - 1++
В (except combustible gases and liquids)	800	A B C D (E)	1++ 2+ - - -	1++ 1++ 1++ - -	1++ 1++ 1+ 1++ 1+	4+ - - - 1+	2+ 3+ 3+ - 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 **14.1** and **14.2**.*

*2. Record the results in table **14.3**.*

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 14.3

Cituation number	**Explosive and fire hazard category**	**Fire Class**	**The total area of the production premises, m^2**
№ 1	В (combustible gases and liquids)		
№ 2	В (except combustible gases and liquids)	E	380
№ 3	A	B	190
№ 4	В (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	Б (except combustible gases and liquids)	B	2000
№ 8	Г (excluding flammable gases and liquids).	C	790

Table 14.4

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 #15: EVALUATION OF THE EXPLOSIVE ENVIRONMENT

Purpose of this work: to obtain the necessary practical skills for the ability to evaluate explosive environment at the machine-building plant by calculation methods.

Statement

The storehouse with ***Q*** tones of explosive matter is located at the distance ***L*** from the machine-building plant workshop. Explosive industrial entity is not only the one where the explosives (trotyl, tetryl, hexogen etc.) are produced or kept; combustible materials and mixtures (coal dust, wood flour, castor sugar etc.) or fine finders also burst. Explosions result by buildings decay, equipment failure, fires, injuries etc.

Task

It's necessary to make the prognosis and evaluate explosive environment in the case of detonation at the industrial entity workshop according to the initial data, ***table 15.8.***

1. To determine the level of destruction of the workshop elements.
2. To define the expected character of fires.
3. To specify the manufacturing staff injuries.
4. To make conclusions and represent recommended guideline.

Report

1. student's first name, family name, group and variant;
2. possible influence of the detonation on the employees;
3. expected character of fires;
4. summary tabulation;
5. conclusions and recommended guideline.

Summary table 15.1

Area of destruction	**Workshop elements**	**Level of destruction**	**Fire situation**	**Staff injuries**
$\Delta P_f =$ … kPa	1.			
	2.			
	3.			
	4.			
	5.			

Buildings and equipment destruction dimension depends on their resistibility and a shock wave dynamic pressure value ΔP_f. The dynamic pressure, in the turn, depends on the amount ***Q*** of the explosive material and the distance L to the center of explosion. Correction factors K_{ES} are used while the dynamic pressure calculation for the certain explosives:

$$K_{ES} = \begin{cases} 1.0 & trotyl \\ 0.97 & picrin \quad acid \\ 1.08 & tetryl \\ 1.28 & hexogen \end{cases}, \tag{15.1}$$

The value is put in the resulted formula:

$$\boldsymbol{Q = K_{ES} \bullet Q_{ES}}, \tag{15.2}$$

where $\boldsymbol{Q_{ES}}$ is the amount of the explosive material, ***t*** according to the initial data.

The value of dynamic pressure can be defined by the graphs (Fig. 15.1).

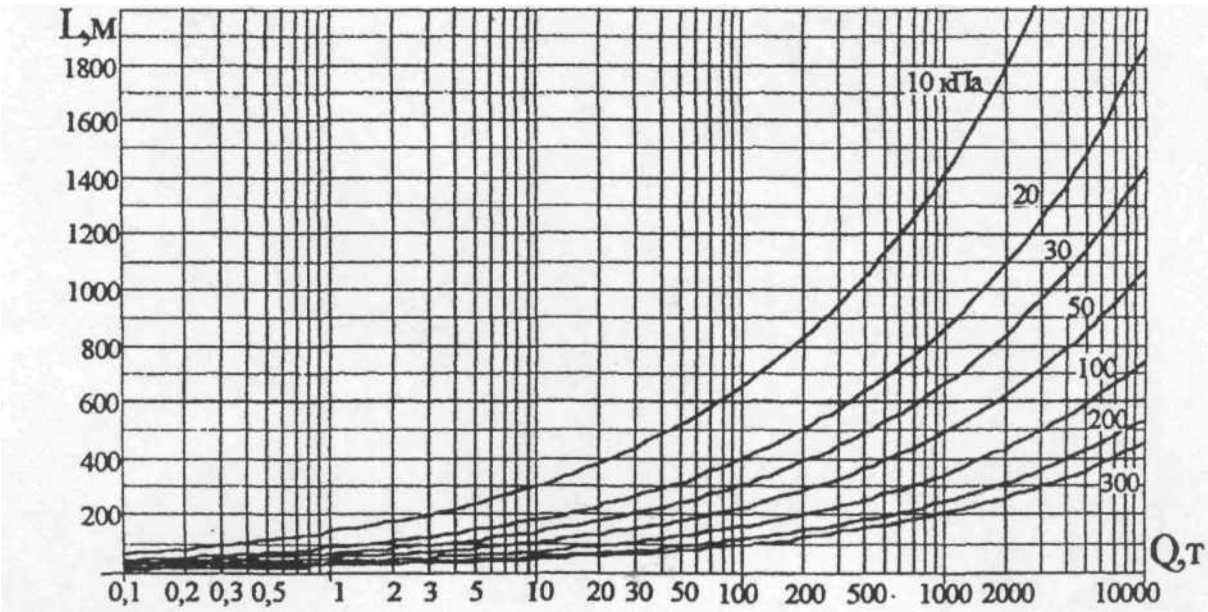


Fig. 15.1. Graphs of dynamic pressure dependence from the amount of trotyl and the distance to the center of explosion.

Separate or continuous fires will appear at the machine-building plant workshop as a result of explosions and depend on:

- the degree of buildings destruction in the explosion;
- fire danger rating;
- buildings refractory properties;
- floor space index;
- weather conditions etc.

The expected character of fires can be determined by the tab. 15.2.

Table 15.2

Predicted Fire Situation, Depending on the Dynamic Pressure, ΔP_f

	Construction site development and fire resistant pattern	**Buildings refractory property**	**ΔP_f, kPa**	**The expected character of fires**	
				first 30 min	**in 1-2 hours after the explosion**
1	Built-up area (both urban and industrial), fire danger ratings C, D, E	IV, V III I, II	10-20 >20 20-50	Separate fire seats	Continuous fires at the floor space index: FSI >10% FSI >20% FSI >30%
2	Industrial built-up area, fire danger ratings A, B		10-50	Separate fire seats, that quickly grow towards continuous and accompanied by the explosions and destruction of production equipment	

Table 15.3

Level of Destruction, Depending on the Dynamic Pressure, ΔPf

	Level of destruction	**Offices and workshops**	**Industrial equipment (machine tool stations, assembly lines, generators etc.)**
1	Weak	Destruction of door and window cuts fillings, disruption of a roof	Damage of certain elements of equipment, steering control levers, measuring devices
2	Middle	Destruction of a roof, light internal partitions, breaches appear in the main walls	Damage and deformation of basic details, electric circuit wirings, automatic control devices, pipelines ruptures
3	Strong	Considerable deformation of load-bearing elements, most floor structures and walls destruction	Single footing inset, machine tool stations deformation, cracks in component parts, cable links and pipelines bursting
4	Complete	All bearing constructions and ceilings are blasted	Transmission towers destruction and pipelines damage at considerable premises, the equipment becomes unserviceable and beyond economic repair

Depending on the dynamic pressure ΔP_f rate people can get traumas, which are graded into light, mean, heavy and extra heavy (tab. 15.4).

Table 15.4

Employees Damage Level, Depending on the Dynamic Pressure, ΔP_f

№	ΔP_f, kPa	Traumas	Damage nature
1	20 - 40	Light	Light blast body injuries, partial hearing loop, joint dislocations
2	40 - 60	Mean	Mean blast body injuries, loop of auditory acuity, nose bleeding, othemorrhagia, broken limbs
3	60 - 100	Heavy	Heavy blast body injuries, visceral injuries, brain contusions, compound fractures
4	>100	Extra-heavy	Most people die

Table 15.5

Industrial Entity Damage Level, Depending on the Dynamic Pressure, ΔP_f

№	Industrial entity elements	Level of destruction			
		Weak	Middle	Strong	Complete
1	*2*	*3*	*4*	*5*	*6*
1.	**Production facilities, offices and workshops**				
1.1	Concrete and reinforced-concrete buildings and structures of anti-seismic construction	25-35	80-120	150-200	200
1.2	Light metal half-timbering structures and frameless structures	10-20	20-30	30-50	50-70
1.3	Precast concrete structures	10-20	20-30	30	30-60
1.4	Brick warehouses	10-20	20-30	30-40	40-50
1.5	Administrative multistory buildings with concrete and reinforced-concrete structures	20-30	30-40	40-50	50-60
1.6	Brick low-storied buildings (one-two floors)	8-15	15-25	25-35	35-45
1.7	Brick multistory buildings (three floors and more)	8-12	12-20	20-30	30-40
2.	**Certain types of equipment**				
2.1	Heavy-duty machine tools	25-40	40-60	60-70	more than 70
2.2	Medium machine-tools	15-25	25-35	35-45	more than 45
2.3	Light machine-tools	6-15	15	15-25	more than 25
2.4	Taps and tap groups	20-30	30-50	50-70	70
2.5	Belt-on conveyors in a gallery of the reinforced concrete piers	5-6	6-10	10-20	20-40

Table 15.5 (cont.)

2.6	Bucket conveyer in a gallery of the reinforced concrete piers	8-10	10-20	20-30	30-50
2.7	Opened electric motor having a capacity of 2 - 10 kW	30-50	50-70	70-80	80-90
2.8	Transformers having a capacity of 100 - 1000 kV	20-30	30-50	50-60	60
2.9	Generators having a capacity of 100-300 kW	30-40	50-60	more than 60	more than 60
2.10	Opened distributing apparatus	15-25	25-35	more than 35	more than 35
2.11	Oil circuit breakers	10-20	20-30	more than 30	more than 30
2.12	Control and measuring equipment	5-10	10-20	20-30	30
3. Public power systems and structures					
3.1	Gasholders and ground storage tanks	15-20	20-30	30-40	40
3.2	Ground metallic reservoirs and capacities	30-40	40-70	70-90	90
3.3	Underground cable networks	200-300	300-600	600-1000	1500
3.4	Ground cable networks	10-30	30-50	50-60	60
3.5	Ground pipelines	20	50	130	more than 130
3.6	Pipelines on metallic or reinforced concrete piers	20-30	30-40	40-50	more than 50

Table 15.6

Categories of Production Relative to the Risk of Fire

Category	Type of production
A	Metal sodium and potassium treatment workshops, hydrogen stations, combustible gas tanks warehouses, gasoline warehouses, acid and alkaline electric power storages warehouses etc.
B	Powdered coal and wood flour workshops, synthetic rubber workshops, power-stations fuel-oil handling system etc.
C	Woodworking workshops, fabric industry and paper making industry workshops, fuel and lubricant warehouses, sheltered coal warehouses, vehicle sheds etc.
D	Casthouses, hammer press shops, welding workshops, hot rolling workshops, hot processing workshops, power-stations main housings etc.
E	Cold metal working workshops, tool workshops, dairy-and-meat industry cold processing workshops, power-stations pumping and power intake equipment etc.

Table 15.7

Buildings Refractory Properties, Hours

Degree	**Construction units**		
	Bearing walls	Floorings	Bearing partitions
I	Non-combustive, 3 h	Non-combustive, 1,5 h	Non-combustive, 1 h
II	Non-combustive, 2,5 h	Non-combustive , 1 h	Non-combustive, 0,75 h
III	Non-combustive, 2 h	Partially-combustive, 0,75 h	Partially-combustive, 0,5 h
IV	Partially-combustive, 0,5 h	Partially-combustive, 0,25 h	Partially-combustive, 0,25 h
V	Combustive	Combustive	Combustive

Table 15.8

Initial Data for the Evaluation of the Explosive Environment

No.	**Description and units of measuring**	**Variants**											
		1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***
1	Distance from a workshop to the storehouse, km	1.1	1	1	0.9	0.7	0.8	0.7	0.6	0.5	0.45	0.8	0.75
2	Type of the explosive material	PROPANE				TROTYL				TETRYL			
3	Mass of the explosive material, t	1,000	800	600	400	200	1,000	800	600	500	200	1,000	800
4	Workshop: one/two-stored building	brick-built			precast concrete		with light metal half-timbering structures				frameless structures		
	Refractory property , hours;												
	a) bearing walls	2.5	2	2.5	2	2.5	0,5	2	0.5	2	0.5	2	0.5
	b) bearing partitions	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Equipment:												
	machine tool stations	heavy		middle-weight		light		middle-weight		light		middle-weight	
	pipelines	ground			on trestles			ground			on trestles		
	cable connections	surface-mounted											
	control and measuring equipment	available											
5	Fire danger rating	B	C	D	E	B	C	D	E	C	C	D	E
6	Floor space index ***FSI***, %	10	20	30	20	10	20	30	20	10	20	20	30

Table 15.8 (cont.)

No.	Description and units of measuring	Variants											
		13	***14***	***15***	***16***	***17***	***18***	***19***	***20***	***21***	***22***	***23***	***24***
1	Distance from a workshop to the storehouse, km	0.6	0.5	0.45	0.8	0.7	0.6	0.55	0.7	0.6	0.6	0.7	0.5
2	Type of the explosive material	TETRYL		TRINITROPHENOL					HEXOGEN				
3	Mass of the explosive material, t	600	500	200	1,000	800	600	500	800	600	500	700	200
4	Workshop: one/two-stored building	with light metal half-timbering structures			precast concrete		with light metal half-timbering structures				brick-built		
	Refractory property , hours;												
	a) bearing walls	2	0,5	2	2,5	2	2	0,5	2,5	2,5	2	2	0,5
	b) bearing partitions	0.75	0.25	0.75	1	0.75	0.75	0.25	1	1	0.75	0.75	0.25
	Equipment:												
	machine tool stations	heavy		middle-weight		light		middle-weight		heavy		light	
	pipelines	ground			on trestles			ground			on trestles		
	cable busses	surface-mounted											
	control and measuring apparatus	Available											
5	Fire danger rating	B	C	D	E	B	C	D	E	C	C	D	E
6	Floor space index ***FSI***, %	10	20	30	20	10	20	30	20	10	20	20	30

TOPIC #16: EVALUATION OF THE CHEMICAL ENVIRONMENT

Purpose of this work: to obtain the necessary practical skills for the ability to evaluate chemical environment at the machine-building plant by calculation methods.

Statement

Chemically dangerous industrial unit is situated at a distance R from the machine-building plant.

A possible accident at the chemically dangerous industrial unit resulted by a chemical substance spreading by the wind, may cause the formation of an area of chemical contamination.

Task

To evaluate chemical environment at the machine-building plant, according to the initial data, ***table 16.7.***

1. to calculate depth, width and the area of chemical contamination;
2. to determine the time when a cloud of contaminated air approaches the machine-building plant;
3. to determine the exposure time of toxic agents;
4. to identify possible influence of the chemical substance at the employees of the machine-building plant.

Report

1. student's first name, family name, group and variant;
2. area of chemical contamination depth: D = ... km ;
3. area of chemical contamination width: W = ... km ;
4. area of chemical contamination: S = ... km2 ;
5. the contaminated air arrival time to the machine-building plant: t ... min;
6. toxic agents exposure:
   a) in summer T_{se} ***... min***;
   b) in winter T_{we} ***... min***;
7. possible influence at the employees of the machine-building plant:
   a) in the buildings ***… %***;
   b) outside the buildings ***… %***

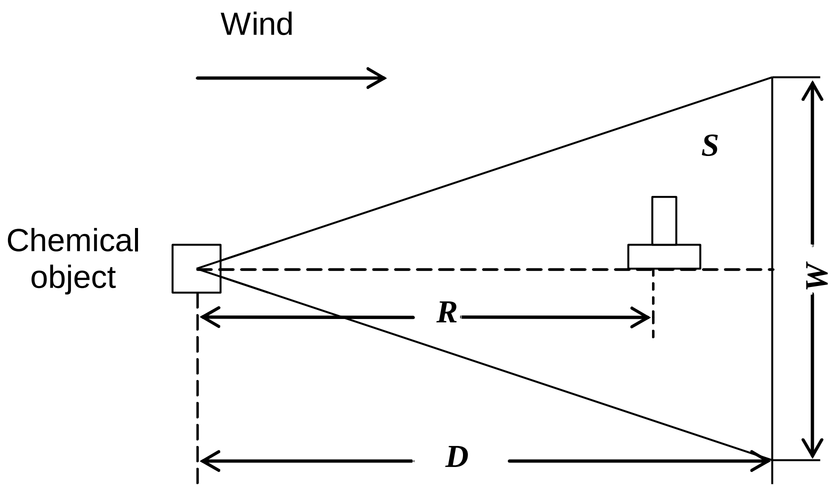


Fig. 16.1.

To determine the ***depth*** of the area of chemical contamination is necessary to use ***tables 16.1*** and ***16.2.***

Table 16.1 is for **unenclosed ground**, wind speed is 1m/sec, non-diked tank with the chemical substance.

Table 16.2 is for **closed ground**, wind speed is 1m/sec, non-diked tank with the chemical substance.

If the wind speed is ***more than 1m/sec*** it's necessary to use correction index from the ***table 16.3.***

If the tank with the chemical substance ***is diked,*** the depth of the area of chemical contamination will be ***less by factor of 1,5***.

To determine the ***width*** of the area of chemical contamination is necessary to use one of the ***formulas - 16.1, 16.2, and 16.3***, with relation to ***atmospheric stability status***:

$$W = 0{,}03 \cdot D \text{ – inversion,} \quad (16.1)$$

$$W = 0{,}15 \cdot D \text{ – homeothermy,} \quad (16.2)$$

$$W = 0{,}8 \cdot D \text{ – convection.} \quad (16.3)$$

To determine the ***area of chemical contamination*** is necessary to use the formula ***16.4***:

$$S = 0{,}5 \cdot W \cdot D. \quad (16.4)$$

The contaminated air arrival time to the machine-building plant is determined according to the ***formula 16.5***:

$$t = \frac{R}{F}. \quad (16.5)$$

F - average speed of the cloud, gassed by the chemical substance, depends on the wind speed ***V*** and the distance ***R***. It can be found from the ***table 16.4.***

Toxic agent exposure ***for the non-diked tank*** is calculated according to the formula:

$$T = \frac{\rho \cdot 4 \cdot 10^5}{P_s \cdot \sqrt{M}(5,38 + 4,1 \cdot V)} \qquad (16.6)$$

Toxic agent exposure ***for the diked*** tank is calculated according to the formula:

$$T = \frac{G}{S_D} \cdot \frac{8 \cdot 10^6}{P_s \cdot \sqrt{M}(5,38 + 4,1 \cdot V)} \qquad (16.7)$$

Where T - toxic agent exposure, *min*;

P_s – air pressure, *kPa*;

M - molar weight, *g/mol*;

V – wind speed, *m/sec*;

ρ – density, t/m^3;

G – mass of the chemical toxic agent, *t*;

S_D – diking area, m^2.

Table 16.1

Chemical Agent	**Mass, *tones***					
	5	10	25	50	75	100
Inversion						
Chlorine, Phosgene	23	49	80	More than 80		
Ammonia	3,5	4,5	6,5	9,5	12	15
Sulphur dioxide	4	4,5	7	10	12,5	17,5
Homeothermy						
Chlorine, Phosgen	4,6	7	11,5	16	19	21
Ammonia	0,7	0,9	1,3	1,9	2,4	3
Sulphur dioxide	0,8	0,9	1,4	2	2,5	3,5
Convection						
Chlorine, Phosgen	1	1,4	1,96	2,4	2,85	3,15
Ammonia	0,21	0,27	0,39	0,5	0,62	0,66
Sulphur dioxide	0,24	0,27	0,42	0,52	0,65	0,77

Table 16.2

Chemical Agent	**Mass, *tones***					
	5	10	25	50	75	100
Inversion						
Chlorine, Phosgen	6,57	14	22,85	41,14	48,85	54
Ammonia	1	1,28	1,85	2,71	3,42	4,28
Sulphur dioxide	1,14	1,28	2	2,85	3,57	5
Homeothermy						
Chlorine, Phosgen	1,31	2	3,28	4,57	5,43	6
Ammonia	0,2	0,26	0,37	0,54	0,68	0,86
Sulphur dioxide	0,23	0,26	0,4	0,57	0,71	1,1
Convection						
Chlorine, Phosgen	0,4	0,52	0,72	1,0	1,2	1,32
Ammonia	0,06	0,08	0,11	0,16	0,2	0,26
Sulphur dioxide	0,07	0,08	0,12	0,17	0,21	0,3

Table 16.3

V – wind speed, m/sec		**2**	**3**	**4**	**5**
Correction index	Inversion	0,6	0,45	0,38	-
	Homeothermy	0,71	0,55	0,5	0,45
	Convection	0,7	0,62	0,55	-

Table 16.4

V – wind speed, *m/sec*	**Inversion**		**Homeothermy**		**Convection**	
	R≤ 10 km	***R>10 km***	***R≤ 10 km***	***R>10 km***	***R≤ 10 km***	***R>10 km***
1	2	2,2	1,5	2	1,5	1,8
2	4	4,5	3	4	3	3,5
3	6	7	4,5	6	4,5	5
4	-	-	6	8	-	-

Table 16.5

Chemical Agent	**M - molar weight, *g/mol***	**ρ – density, *t/m³***	**P_s – air pressure, *kPa***	
			$t^0 = +15^0 C$	$t^0 = -10^0 C$
Chlorine	71	1,56	575	250
Phosgene	99	1,42	140	50
Ammonia	17	0,68	680	300
Sulphur dioxide	64	1,46	280	110

Table 16.6

Conditions	% **Gas mask availability**									
	0	20	30	40	50	60	70	80	90	100
In the buildings	50	40	35	30	27	22	18	14	9	4
Out of the buildings	90-100	75	65	58	50	40	35	25	18	10

Table 16.7

INITIAL DATA FOR THE CHEMICAL ENVIRONMENT EVALUATION

Preset Parameters	**Variants**											
	1	2	3	4	5	6	7	8	9	10	11	12
Chemical toxic agent	PHOSGENE					SULFUR DIOXIDE					CHLORINE	
Mass of the chemical toxic agent (G), ***t***	10	25	50	75	100	100	25	50	75	100	10	10
Diking area (S_D), m^2	non-diked	15	non-diked	45	60	non-diked	15	non-diked	40	55	non-diked	non-diked
Distance to the accident site (R), ***km***	4	3	5	6	2	0.7	2.5	1.2	1	0.6	1.3	1.0
Terrain characteristics	unen-closed ground	unen-closed ground	closed ground	closed ground	unen-closed ground	unen-closed ground	unen-closed ground	closed ground	unen-closed ground	closed ground	unen-closed ground	unen-closed ground
Atmospheric stability status	homeothermy		inversion		convection		inversion		homeothermy		convection	
Wind speed (V), m/sec	1	2	3	3	1	1	2	3	2	1	1	2
Gas mask availability, %	50	60	70	80	90	100	50	60	70	80	90	100

Table 16.7 (continuation)

Preset Parameters	**Variants**											
	13	14	15	16	17	18	19	20	21	22	23	24
Chemical toxic agent	CHLORINE			AMMONIA					PHOSGENE			
Mass of the chemical toxic agent (G), ***t***	50	75	100	10	25	50	75	100	25	50	75	100
Diking area (S_D), m^2	25	40	55	non-diked	30	non-diked	90	non-diked	non-diked	non-diked	non-diked	non-diked
Distance to the accident site (R), ***km***	9	11	9	0.8	0.6	1.2	2	8	3	2	1.5	2
Terrain characteristics	closed ground	closed ground	unen-closed ground	unen-closed ground	unen-closed ground	closed ground	closed ground	unen-closed ground	closed ground	closed ground	unen-closed ground	unen-closed ground
Atmospheric stability status	inversion		homeothermy		inversion			homeothermy			convection	
Wind speed (V), m/sec	3	3	2	1	2	3	1	2	1	3	3	2
Gas mask availability, %	50	60	70	80	90	100	50	60	70	80	90	100

TOPIC #17: EVALUATION OF THE RADIATION ENVIRONMENT

Purpose of this work: to obtain the necessary practical skills for the ability to evaluate radioactive environment at the machine-building plant by calculation methods.

Statement

A possible accident at radioactively dangerous industrial unit can cause problems for the surrounding and the staff of the machine-building plant.

Task

To evaluate radioactive environment at the machine-building plant, according to the initial data that are listed in the ***table 17.4***:

1. to define the dose of radiation which can be obtained by the group of liquidators;
2. to determine the time of area damage control and recovery operations at the contaminated territory, for the group of liquidators;
3. to identify possible influence at the employees of the machine-building plant.

Report

1. student's first name, family name, group and variant;
2. level of radiation in one hour after the accident: P_1 **= ... *R/hour*** ;
3. dose of radiation which can be obtained by the group of liquidators: ***D* = ... *R*** ;
4. possible time of the area damage control and recovery operations at the contaminated territory, for the group of liquidators:

$$t_W = ...\ hours;$$

5. total dose of radiation: $D_{\sum}$ **=… *R*** ;
6. possible influence at the employees of the machine-building plant: ***L* = … %** .

Determination of the level of radiation in one hour after the accident

P_t – measured level of radiation, ***R***;

P_B – level of radiation at the beginning of the area damage control and recovery operations, ***R***;

P_T – level of radiation when the area damage control and recovery operations are terminated, ***R***;

K_B – the certain time scaling factor for the area damage control and recovery operations beginning;

K_T – the certain time scaling factor for the area damage control and recovery operations termination;

T – the time, when the level of radiation was measured***, hours***;

t_B – the time of the area damage control and recovery operations beginning at the contaminated territory, for the group of liquidators***, hours***;

$\boldsymbol{t_T}$ – the time of the area damage control and recovery operations termination at the contaminated territory, for the group of liquidators***, hours***;

$\boldsymbol{t_W}$ – the total time of the area damage control and recovery operations at the contaminated territory, for the group of liquidators***, hours***;

$\boldsymbol{K_w}$ – weakening of radiation by the buildings factor;

$\boldsymbol{\alpha}$ – auxiliary parameter;

$\boldsymbol{D_{DEF}}$ – defined dose of radiation, ***R***;

$\boldsymbol{D_P}$ – dose of radiation, obtained previously, ***R***;

$\boldsymbol{D_L}$ – lasted dose of radiation, ***R***;

$\boldsymbol{D_\Sigma}$ – total dose of radiation, ***R***.

$$P_1 = P_T \cdot \bar{t}^{1,2} = P_T \cdot K_T \quad (17.1)$$

$$P_B = \frac{P_1}{K_{tB}} \quad (17.2)$$

$$P_T = \frac{P_1}{K_{tT}} \quad (17.3)$$

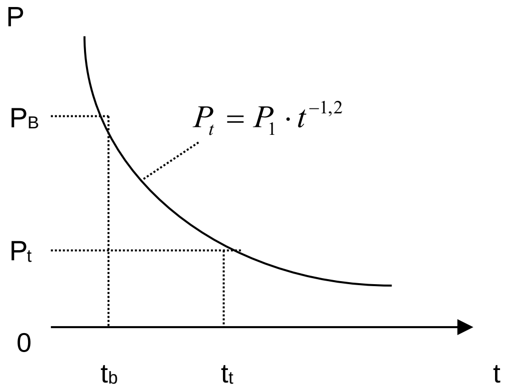


Fig. 2.1

$$D \ = \frac{(\text{Đ}_B t_B - \text{Đ}_T t_T)}{\hat{E}_W}, \quad (17.4)$$

$$\alpha = \frac{\text{Đ}_1}{D_{SET} \cdot \hat{E}_W}. \quad (17.5)$$

$$D_P = D_L \cdot \frac{d}{100}, \quad (17.6)$$

$$D_\Sigma = D \ + Dp \quad (17.7)$$

Table 17.1

The Certain Time Scaling Factor for the Area Damage Control and Recovery Operations

t, hours	K_T	t, hours	K_T	t, hours	K_T
0,25	0,57	2,50	1,44	6	2,04
0,30	0,61	2,75	1,49	6,5	2,11
0,50	0,75	3	1,55	7	2,17
0,75	0,89	3,25	1,60	7,5	2,24
1	1	3,50	1,65	8	2,30
1,25	1,09	3,75	1,69	8,5	2,35
1,50	1,17	4	1,74	9	2,41
1,75	1,25	4,50	1,82	9,5	2,46
2	1,31	5	1,90	10	2,51
2,25	1,38	5,50	1,97	11	2,60

Table 17.2

Lasted Dose of Radiation

d, Time after irradiation, weeks	1	2	3	4	5
D_L, Lasted dose of radiation, *R*	90	75	60	50	42

Table 17.3

Potential Losses

D_Σ, Total dose of radiation, *R*	100	125	150	175	200	225	250	275	300	325
Potential losses, %	0	5	15	30	50	70	85	95	100	100

Table 17.4

Tasks for the Radiation Environment Evaluation (for the water-water energetic reactor (WWER)

Variant	The radiation level at 6:15, P_t, R/hour	The time of the area damage control and recovery operations beginning t_B, hours	The total time of the area damage control and recovery operations, t_w, hours	Defined dose of radiation, D_{DEF}, R	Weakening of radiation by the buildings factor, K_W	Dose of radiation, obtained previously, D_P, R	Irradiation time, T_R, weeks
1	605	6:30	1.5	25	5	14	1
2	330	6:45	1.3	20	4	21	3
3	310	7:15	2.8	15	2	72	2
4	400	7:30	4.0	20	5	9	4
5	430	8:00	2.5	15	4	13	1
6	285	6:45	2.2	25	6	18	3
7	370	7:15	3.8	20	7	75	2
8	350	6:45	2.0	15	5	11	4
9	335	7:30	3.5	25	2	52	1
10	225	6:45	2.8	20	5	19	3
11	280	7:30	4.0	15	7	22	2
12	550	8:00	4.5	25	2	17	4
13	410	7:15	2.7	20	5	10	1
14	390	8:00	2.5	15	4	12	3
15	400	6:30	2.0	25	5	71	2
16	310	6:45	3.2	20	10	25	4
17	450	7:15	4.3	15	5	3	1
18	470	7:30	2.0	25	2	49	3
19	265	6:30	1.5	20	4	17	2
20	525	8:00	2.5	15	2	67	1
21	200	6:30	1.5	25	5	14	2
22	300	7:00	2.5	20	10	20	3
23	250	7:30	3.0	25	4	50	4
24	320	8:00	3.5	20	7	9	1

TOPIC #18: 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 18.1***:

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} = ... ***persons;***
   M_{A2} = ... ***persons;***
3. seating capacity calculated for the volume index: M_{V1} = ... ***persons;***
   M_{V2} = ... ***persons;***
4. minimum seats amount in the protective shelters: M_{min1} = ... ***persons;***
   M_{min2} = ... ***persons;***
5. actual seats number in the both protective shelters : M_1 = ... ***persons;***
   M_2 = ... ***persons;***
6. number of the seats in the 1st air duty: N^1_1 = ... ***persons;***
   N^1_2 = ... ***persons;***;
7. number of the seats in the 2nd air duty: N^2_1 = ... ***persons;***
   N^2_2 = ... ***persons;***
8. number of the seats in the 3rd air duty: N^3_1 = ... ***persons;***
   N^3_2 = ... ***persons;***
9. number of the seats supplied by the water: N_{W1} = ... ***persons;***
   N_{W2} = ... ***persons;***

To obtain ***seating capacity calculated for the area index*** it's necessary to use formula 18.1:

$$M_A = \frac{S\ sh}{S\ nor}\ , \tag{18.1}$$

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

S_{sh} – area of the protective shelter facility, m^2;

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

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

S_{nor} = 0.4 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 18.2:

$$Mv = \frac{(S\ sh + S\ ad)\cdot h}{Vnor}\ , \tag{18.2}$$

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

S_{sh} – area of the protective shelter facility, m^2 ;

S_{ad} – area of additional protective shelter facility, m^2;

h - floor-to-ceiling height, m;

V_{nor} - air volume requirements (per person) : $V_{nor} \geq 1.5\ m^2$.

To obtain ***number of the seats in the 1st air duty*** it's necessary to use formula 18.3:

$$N_1 = \frac{n \cdot V_1}{W_1}\ , \tag{18.3}$$

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, m^3/hour ;

W_1 - air volume requirements (per person) m^3/hour; depends on the climatic region, where the machine-building plant is situated:

I climatic region – 8 m^3/hour ;

II climatic region - 10 m^3/hour ;

III climatic region - 11 m^3/hour ;

IV climatic region - 13 m^3/hour .

To obtain ***number of the seats in the 2nd air duty*** it's necessary to use formula 18.4:

$$N_2 = \frac{n \cdot V_2}{W_2}\ , \tag{18.4}$$

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, m^3/hour ;

W_2 - air volume requirements (per person) m^3/hour, for the 2nd air duty,

$W_2 = 2\ m^3$/hour;

To obtain number of the seats in the 3rd air duty it's necessary to use formula 18.5:

$$N_3 = 150 \cdot m, \quad (18.5)$$

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 18.6:

$$N_w = \frac{B}{B_{nor.} \cdot T}, \quad (18.6)$$

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 18.1

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, m²	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, m²	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-I	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 18.1 (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 18.1 (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