Saimaa University of Applied Sciences

Technology, Lappeenranta

Double Degree Programme in Civil and Construction Engineering

Irina Bazarova

OCCUPATIONAL SAFETY REQUIREMENTS FOR THE WELDING PRODUCTION

Bachelor's Thesis 2013

ABSTRACT

Irina Bazarova

Occupational Safety Requirements for the welding production

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Instructorы: Mr Timo Sihvo, Saimaa University of Applied Sciences; Mr Sergey Scherbina and Matvey Pirozhenko, Peikko Russia

The purpose of the research was to study the welding production process in view of the occupational safety and fire safety.

In the theoretical part of the study the main issue was targeted at researching Russian regulations concerning the safety questions on production. By the use of the reference data the study introduced the recommended way of the production's works organization in a welding factory in particular.

Initial data was taken right on the factory and during the conversation with the Production Manager, the Main Construction Engineer and the Executive Director. Data for this study research was collected from the electronic technical libraries. By the use of the all already mentioned sources several accountancies were made and the preliminary emergency plan was developed.

The main aim of this study was to consider the factory in view of the safety questions and make an attempt to give some characteristics. Then by the use of the reference sources the information about the recommended way of the occupational safety system handling was provided in accordance with the Russian standards and norms.

As a result of this study a list of recommendations for safe works and the key points of the occupational safety control were researched.

Keywords: Russian regulations; production; welding factory; accountancies; emergency plan.

CONTENT

4

1. INTRODUCTION

The purpose of this thesis is to research the welding production process in Russia in view of the occupational safety questions and compare it with the relevant way of safe management described in Standards and Norms on example of the well-known Finnish company which has a subsidiary in Russia for storage, assembly, sales and deliveries of their products.

First of all it is essential to investigate each step of the production process. The initial company description is provided in the following chapter.

Further study structure reveals itself in three main divisions. The first one is devoted to the Peikko company description and indoor and outdoor working conditions and features depending on the machine types, production building structure, working process, etc. Then the second division follows which is mainly devoted to the fire problems and their solution. The last division includes information about safety works in accordance with the different type of job and operation process.

For this research Russian Standards and Norms and standardized software are applied. For the fire situation estimate CFAST 6 is applied, and for the harmful substances concentration in the working area evaluation the ECOLOG software is used.

Each division includes the theoretical parts which describe the main idea how each considered question must be managed in view of the regulations and standards. Then the practical part goes with the relevant accountancies and drawings if needed.

2. COMPANY DESCRIPTION

Peikko Group Corporation is a Finnish company specialized in concrete connections production. It was established in Lahti in Finland and now it has sales offices in some 30 countries in Europe, North America and Middle East. Peikko's modern production facilities are located in Canada, China, Finland, Germany, Lithuania, Russia, Slovakia, the United Arab Emirates and the United Kingdom.

Figure 1.2. Peikko Company in Russia.

2.1 PRODUCTION

The main domain of the Russian subsidiary is production of:

Steel fastening plates KL, P2KL, JPL	
Angle bars UKT	
Fastening elements TR	
Couplers MODIX	
Cantilever Balcony Connector NIRO	
Leave-in-place floor joints TERRA JOINT	
Diagonal ties PD	
Lifting devices JENKA	
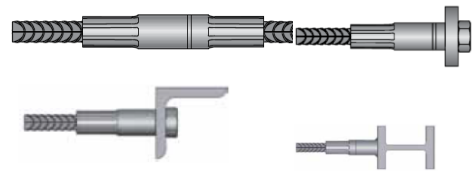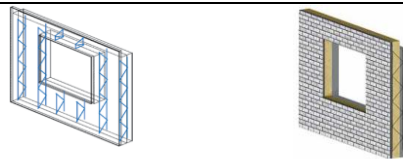
Figure 2.2. Products.

2.2 EMPLOYEES

Company hierarchy:

```
                    Managing
                    Director

    Sales Manager              Production
                                Manager

    Logisticians               Workers
                                  ──── Welding

                                  ──── Storage works

                                  ──── Work on the press

                                  ──── Forklift driving

                                  ──── Packaging

                                  ──── Repairing
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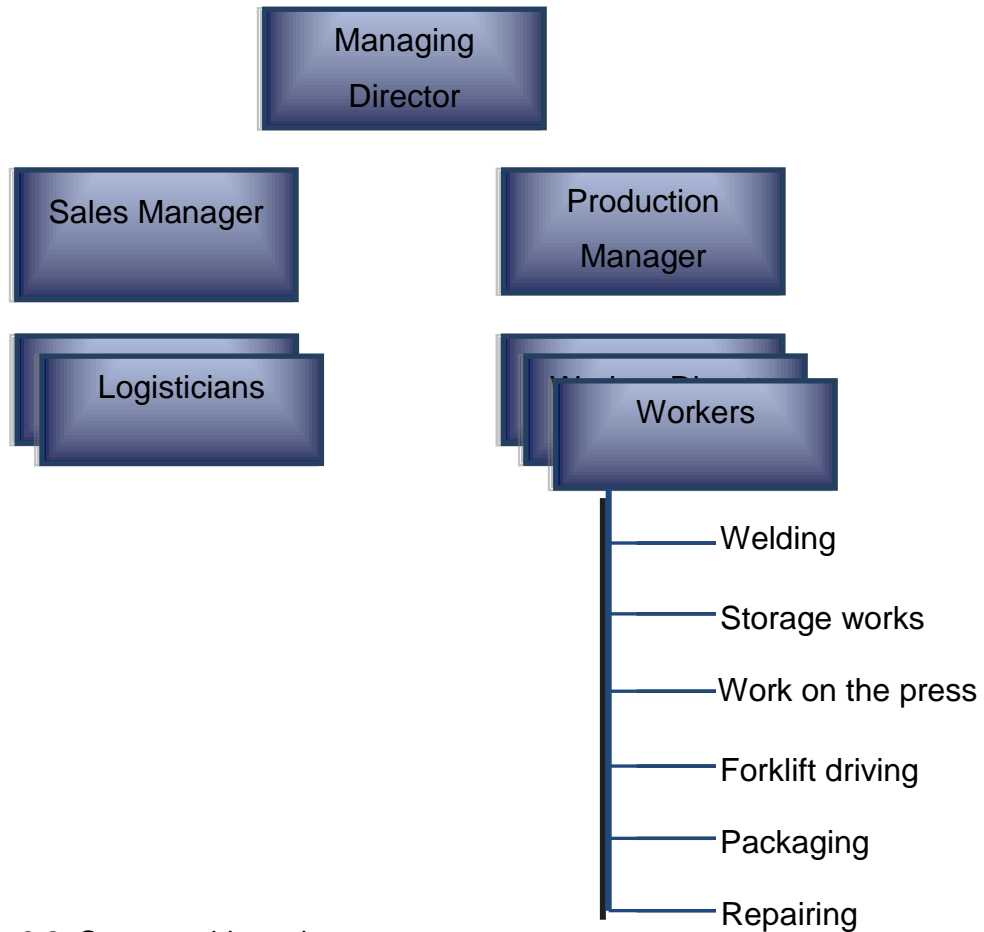
Figure 3.2. Company hierarchy.

2.3 MACHINES AND TOOLS

The production area is divided into several zones.

The first zone is called Terra Joint area. It includes the following equipment: a table for the row material storage; a crimping machine with the linear feed of the row material (Univer CM-423E); a table where the product details are composed and fixed by the pneumatic pressing elements for the following welding process (Kepact Mig 2530); a table for the anchors drawn arc welding on the product surface (28 anchors) and then plastic elements are put on the relevant zones of

the product; ready-made products are transferred by the jib crane (for the maximum load till 125 kg) on the pallet for the packing.

The next zone is the PD area. It includes a PD-machine which produces the diagonal ties. This machine makes the contact welding (KemecWeld KRW 101 PE) of the row materials - several wire coils. The wire from the central coil is prolonged till the required length, and then curved by the use of the hydraulic station. Then the semi-automatic point welding is produced, the detail is measured, the required length is cut and then the diagonal tie is packed into the relevant packages. After that the operator receives the ready-made product and puts it on the storage place.

After that the welding area goes. The semi-automatic welding machine with the cooler (ProMig Pro 4200; ProCool 30) , the welding table with the fixers, the set of the templates for the products, the rotate welding platform, the wooden table for the painting are located there.

In addition a hydraulic pressing machine is put apart of the all earlier mentioned areas. It serves to produce Jenka Modix products. Moreover in the process of the Jenka Modix production the cutting and the bending machines are used.

Besides there are two forklifts: for outside and inside works, hand tools, band-saw with the feeding table.

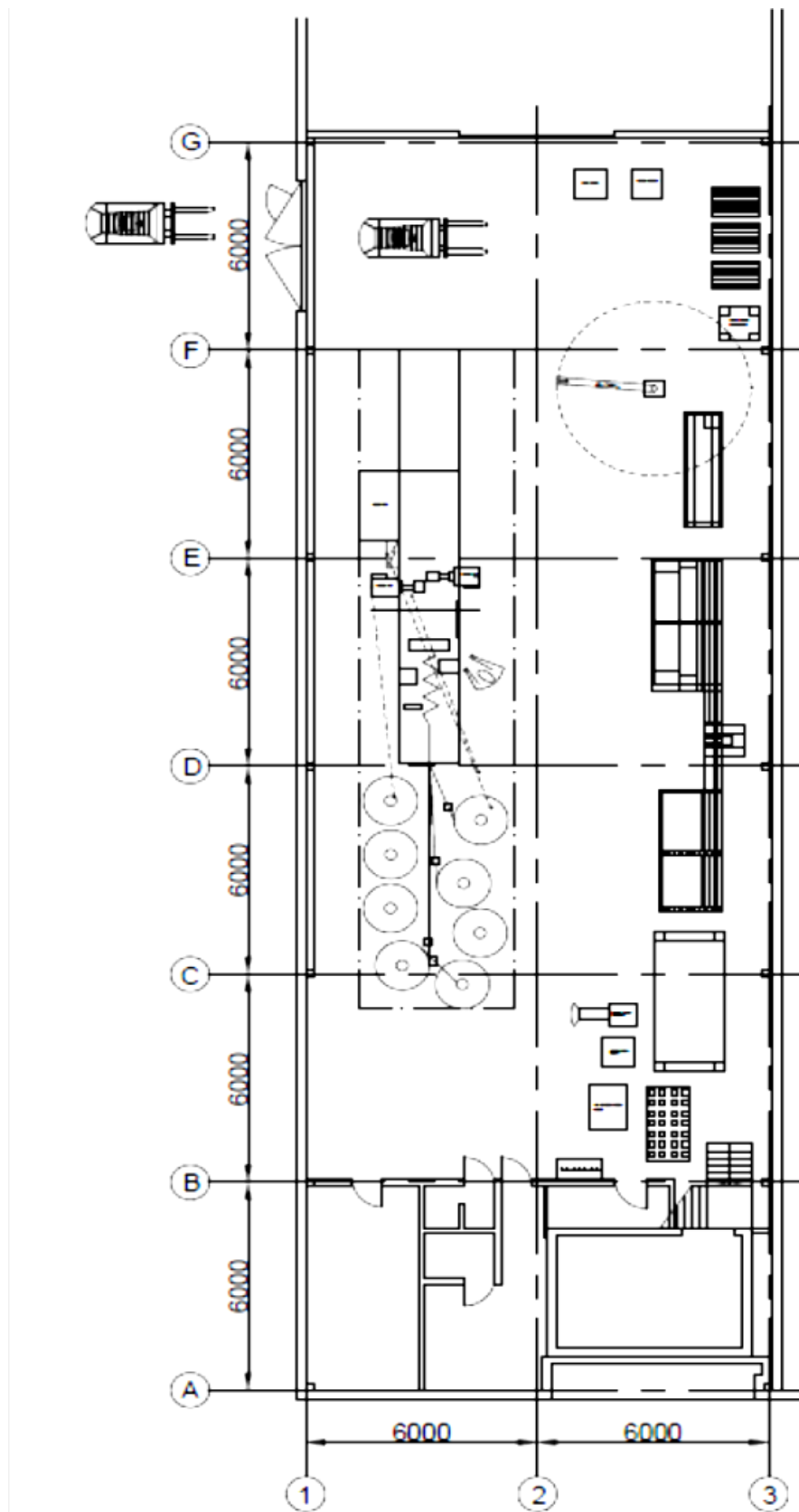## 2.4 DIMENSIONS OF THE PRODUCTION AREA

Figure 4.2. Factory plan.

The type of the works which are performed on the factory can be classified as type III. This means that workers subjected to the intensity of energy consumptions equal more than 250 kcal per hour (more than 290 W), they have to carry and to transfer quite heavy consignment (more than 10 kg) moreover their works imply regular move and substantial physical stress. (R 2.2.013-94, 12.07.94)

The type of the office work can be classified as type IA. This means that workers subjected to the intensity of energy consumptions equal less than 120 kcal per hour (less than 139 W), they conduct their work in the sitting position and are subjected to the minor physical stress.

2.5 OPTIMAL MICROCLIMATE CONDITIONS

The values which characterize the microclimate conditions are the following:

- Air temperature;

- Relative humidity;

- Speed of the air movement;

- Intensity of thermal radiation.

The optimal microclimate dimensions are established for the total working area. The permissible microclimate dimensions are established differentiated for the permanent and for the impermanent working places. (SanPin 2.2.4.548-96, 01.10.96)

The permissible microclimate dimensions are established in cases of impossibility to set the optimal dimensions in view of some technological or economic difficulties. (GOST 12.1.005-88)

In case of providing the optimal microclimate dimensions the temperature of internal structures surfaces (such as walls, floor, ceiling) surrounding the working area or working equipment and the temperature of the external surfaces of the technological equipment or its surrounding structures must not

differ more than 2°C with the optimal microclimate dimensions stipulated in the following table for the particular work types. If the surface temperatures of enclosures exceed or belittle the optimal temperature dimensions, the working places must be installed by the distance less than 1 m form this enclosures.

In accordance with GOST 12.1.005-88 the microclimate of the production premises must be satisfied by the following dimensions:

SEASON	WORK TYPE	TEMPRETURE, °C					RELATIVE HUMIDITY		SPEED OF AIR MOVEMENT, m/s	
		OPTIMAL	PERMISSEBLE							
			UPPER LIMIT		LOWER LIMIT					
			AT THE WORKING PLACES							
			PERMANENT WORKING PLACES	IMPERMANENT WORKING PLACES	PERMANENT WORKING PLACES	IMPERMANENT WORKING PLACES	OPTIMAL	PERMISSIBLE	OPTIMAL	PERMISSIBLE
Cold	Easy-IA	22-24	25	26	21	18	40-60	75	0,1	Not more than 0,1
	Difficult-III	16-18	19	20	13	12	40-60	75	0,3	Not more than 0,5
Warm	Easy-IA	23-25	28	30	22	20	40-60	55 (in case of 28 °C)	0,1	0,1-0,2
	Difficult-III	18-20	26	28	15	13	40-60	75 (in case of 24 °C and lower)	0,4	0,2-0,6

Table 1.2. Microclimate conditions.

In adjustment of the working area the temperature differential is allowed till 3°C. The allowed temperature differences across the working area are to be less than 4°C – for easy works, and less than 6°C – for difficult works. (GOST 12.1.005-88)

2.6 DESCRIPTION OF THE BUILDING STRUCTURE

The structure of the building consists of the columns and slabs.

The foundation of the outside walls consists of the brick 0.4 m in width. The upper part of the wall includes the following: metal cassettes which serve to support the thermal insulation material. In this case it is two layers of Rockwool Light Batts 70 mm and 80 mm in width, two layers of the Rockwool Light Batts 100 mm in width each of the layer and two layers of the fire-resistant Gyproc. The total wall width is equal to 350 mm.

Columns are included in the wall structure. At the level of the first floor metal columns are surrounded by the Rockwool Conlit 50 mm in width and then goes the layer of the one half brick. At the level of the third floor the structure is different. It consists of the 50 mm Rockwool Conlit, then the 100 mm Rockwool Light Batts is possessed and then there are two layers of the fire-resistant Gyproc Glasroc F.
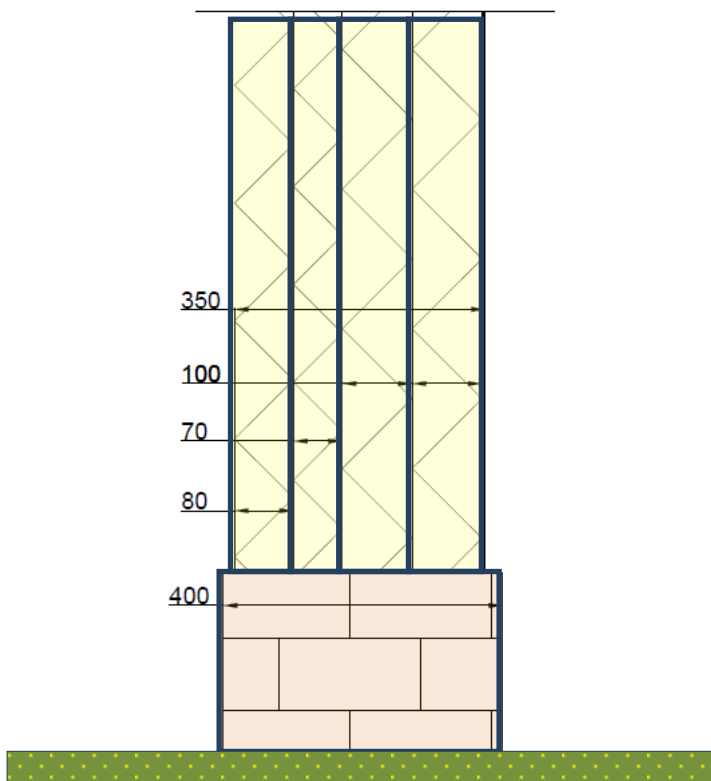
Figure 5.2. External wall section
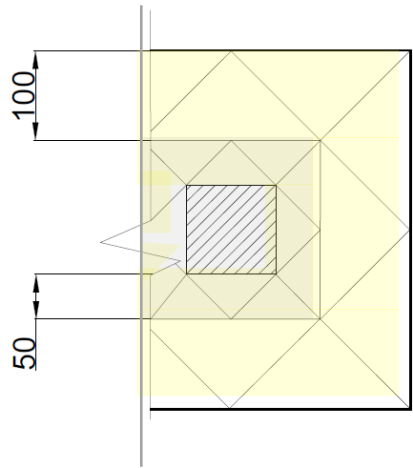
The Structure of the column on the 3rd floor
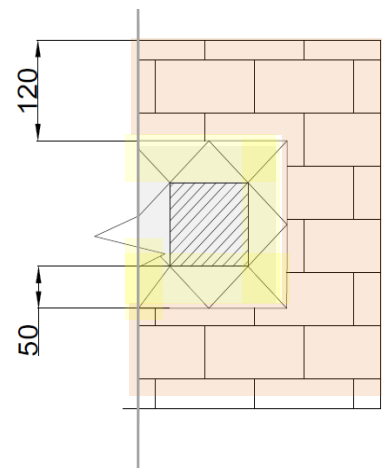
The Structure of the column on the 1st floor

Figure 6.2. Envelope structures.

The total width of the heat insulation material inside the external wall structure is 350 mm.

All bearing elements are made of steel.

Outside the wall surface the water and wind metal barrier is installed.

Internal walls are made of brick or gazconcrete.

Firefighting system is not organized yet but will be installed in future.

The system of fire water is established.

FIRE RESISTANT WALL
OF THE 2nd TYPE

FIRE RESISTANT WALL
OF THE 2nd TYPE

PEIKKO

15   Figure 7.2. First floor plan
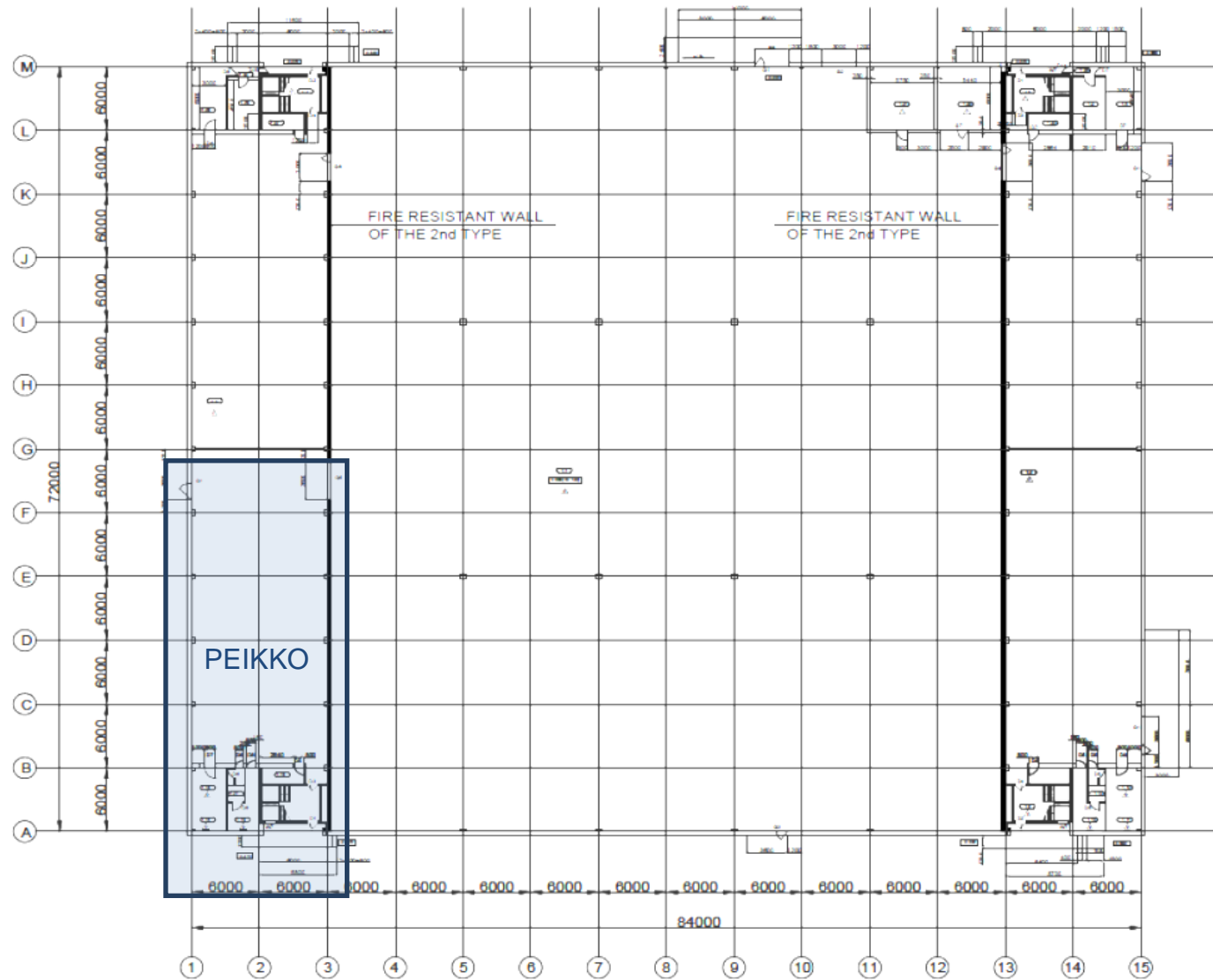
2.7 BUILDING MATERIAL CHARACTERISTICS

- **Rockwool Conlit:**

Combustibility	NG
Fire prevention class	M0
Density	165 kg/m^3
Thermal conductivity	λ_{10} = 0,036 W/(м·К)
	λ_{25} = 0,038 W/(м·К)
	λ_{125} = 0,049 W/(м·К)
	λ_{300} = 0,075 W/(м·К)
Dimensions of the plate	length – 2000 mm
	width – 1200 mm
	thickness – 50 mm

Table 2.2. Rockwool Conlit characteristics.

Together with the metal elements of the building structure, such as a metal column, it can be possible to achieve fire resistance 240EI.

In accordance with SNiP 21-01-97 Fire Safety of Buildings and Works for inflammable building materials there is no need to provide any other fire danger rating.
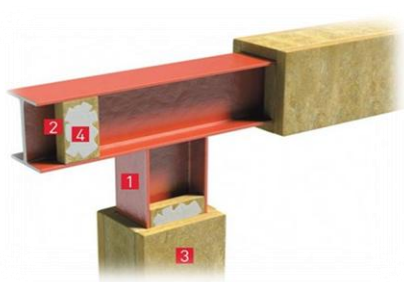
1. Metal element (beam or column);

2. Conlit SL 150;

3. Fire resistant layer Conlit SL 150;

4. Conlit Glue.

Figure 8.2. Structural joint.

- **Gyproc plates:**

Their main purpose is to serve as the internal finishing material.

Combustibility	G1
Fire prevention class	KM1
Surface density	11,7
Thickness of the plate	12,5 mm
Flammability	B1

characteristics.

Table 3.2. Gyproc plate characteristics.

- **Glasroc F:**

The fire resistant plate consists of gypsum core, which is reinforced by the glassfibre and enhanced by the nonwoven glass canvas through the total volume from both sides.

The front and back surfaces of the nonwoven glass canvas are protected by the thin gypsum plaster layer (1-1.5 mm). The face Glasroc F has a strong smooth white surface that does not require finishing.
Building structures including Glasroc F provide fire resistance equal to 240EI.

The finishing of the metal elements by the Glasroc F is provided by the erection plates using a self-tapping screw or staples.

Figure 9.2. Column structure

Combustibility	NG
Fire prevention class	KM0
Thickness of the plate	50 mm

Table 4.2. Glasroc F characteristics.

- **Rockwool Light Batts**:

Combustibility	NG
Fire prevention class	M0
Thickness of the plate	100 mm
Thermal conductivity	λ10 = 0,036 W/(м·К)
	λ25 = 0,037 W/(м·К)
	λA = 0,039 W/(м·К)
	λБ = 0,041 W/(м·К)

Table 5.2. Rockwool Light Batts characteristics.

Peikko's occupancies category of the fire and explosion risk can be determined as G in view of materials applied in the building structure.

2.8 CALCULATION OF THE HARMFUL SUBSTANCES RELEASED DURING THE WELDING PROCESS

During the welding process different substances release, the main part of which compose   solid particulars and gases. Especially the most substantial air pollution is caused by the welding with the use of electrodes with the high quality coatings. The content of the dust and gases is determined by the electrode coating composition and the content of the welded material and the electrode metal. Welding dust is a mixture of small particulars of the metal oxides and the minerals. The main components of the welding dust are iron oxides (till 70%), manganese oxides, silicon oxides, chromium oxides, fluoride and other compounds. The most harmful substances which compose the electrode coating and the electrode metal are chromium, manganese and fluoride. The air of the welder working zone is polluted by the different gases such as: nitrogen oxide, carbon, hydrogen fluoride, etc. (GOST 12.1.005-88) During the gas metal cutting the welding aerosol, manganese oxides, chromium oxides, nitrogen and carbon release.

The removal of the harmful gases and dust from the area of the cutting and welding and the clean air's supply is performed by the local and general ventilation system. The volume of the supplied fresh air must not be less than 30 m^3/h. Inside the closed spaces welding is forbidden without the ventilation system. Therefore if the electrode's consumption during one hour is less than 0.2 kg per 1m^3 of the premise volume and the welding dust concentration is less than the maximum limited value, the natural ventilation is allowed. The values of the maximum permissible concentration (MPC) of the harmful substances are introduced in the following table.

If the welding and the gas cutting are performed in the same factory, all consumptions are to be summarized in both processes in case of the total emission of any admixtures determination.

The estimation of the harmful substances which release during the welding process is determined in accordance with the electrode mass flow rate calculation.

The maximum permissible concentration of the harmful substances which release in the air during the welding or metal cutting:

Substance	MPC in the working area air, mg/m^3
Solid component of the welding aerosol	
Manganese (in case of its content in the welding aerosol not more than 20%)	0,2
Iron oxide	6,0
Silicon dioxide	1,0
Chromium oxide (III)	1,0
Chromium oxide (VI)	0,01
Zinc oxide	6,0
Gas component of the welding aerosol	
Nitrogen oxide	2,0
Manganese oxide	0,3
Ozone	0,1
Carbon monoxide	20,0
Hydrogen fluoride	0,5/1,0

Table 6.2. GOST 12.1.005-88 SSBT. General hygiene requirements to the working zone air.

The total amount of the harmful substances released during the arch welding per 1kg of spent electrode can be calculated:

$$G_i = 10^{-3} g_i \cdot B, \text{ (1.2)}$$

where

g_i – is the emission per 1 m^3 ith component per 1 kg of the spent electrodes,

B – is the mass of the spent electrodes during the particular period of time (one hour, one year, etc.)

The maximum one-time emission of the released harmful admixtures of the ith component during the welding can be determined using the following equation:

$$M_i = \frac{g_i \cdot B}{3600 \cdot \tau}, \text{ (2.2)}$$

where

B – is the maximum quantity of the electrodes, which were spent during the one working time, kg;

τ - is the time of the welding process holding, h.

The calculation of the harmful substances which release during the metal cutting process is determined on the base of the working time calculation. The

20

total amount of the harmful admixtures of the i[th] component during the cutting process is determined using the following equation:

$$G_{ip} = 10^{-3} \cdot g_{ip} \cdot \tau_p$$, (3.2)

where

g_{ip} – is the emission of the i[th] component per 1 m^3 during the metal cutting process for one hour work, the values of this emission are introduced in the table

τ_p – is the time of the cutting process, h.

Emissions of the harmful admixtures per 1 m^3 during the metal gas cutting for one hour:

Type of the cutting metals	Sheet thickness, mm	Harmful admixtures emission, g/h				
		Welding aerosol	Manganese oxides	Carbon oxides	Nitrogen oxides	Chromium oxides
Steel Carbon, low alloy	5	74,0	2,31	49,5	39,0	–
	10	131,0	3,79	63,4	64,1	–
Steel High quality, stainless	5	82,5	–	42,9	33,6	3,96
	10	145,5	–	55,2	43,4	6,68

Table 7. 2. Emissions of the harmful admixtures.

The maximum one-time emission of the harmful admixtures of the i[th] component during the gas cutting process can be determined using the following equation, g/s:

$$M_i = \frac{g_i}{3600}$$ (4.2)

PD area

For the substance release determination during the welding processes the calculation methods with the use of the specific indicators of the pollutant emissions are applied.

The calculation of the pollutant emissions is provided in accordance with the "Guidelines for the pollutant emissions calculation in terms of welding process".

The quality and quantity characteristic of the contaminants released into the atmosphere is introduced in the following table:

Contaminant		Gas cleaning, %	Maximum one-time release, g/s		Annual emission, t/year	
Code	Name		Before cleaning	After cleaning	Before cleaning	After cleaning
123	Ferrum oxide	-	0,0007244	0,0007244	0,0016103	0,0016103
143	Manganese and its compounds	-	0,0001794	0,0001794	0,0003989	0,0003989
2908	Inorganic dust containing 70-20% SiO2	-	0,0000406	0,0000406	0,0000903	0,0000903

Table 8.2. Characteristic contaminants released into the atmosphere.

Initial data for the pollutant emissions calculation are introduced in the table:

Name	Design parameter		
	Characteristic, designation	Unit	Value
Semi automatic welding machine with the use of the electrode wire Sv-0,81G2S. The welding is produced in the CO$_2$ gas environment. Specific factor of the contaminant "x" per one unit of the consumable materials and row products, K^x_m:			
123. Ferrum oxide		g/kg	7,67
143. Manganese and its compounds		g/kg	1,9
2908. Inorganic dust containing 70-20% SiO2		g/kg	0,43
Standardized value of the expenditure cinders releasing from the electrodes, n_o		%	15
Consumption of the welding materials during one year, B''		kg	617,5
Consumption of the welding materials during the intense work period, B'		kg	1
Intense work time, τ		h	1
Local suction effectiveness, η in the fractions of the unit:			
123. Ferrum oxide		-	0,4
143. Manganese and its compounds		-	0,4
2908. Inorganic dust containing 70-20% SiO2		-	0,4
Simultaneity of the work		-	yes

Table 9.2. Initial data for the pollutant emissions calculation.

The quantity of the contaminants which are released into the environment during the welding materials consumption is determined using the following equation:

$M_{bi} = B \cdot K^x_m \cdot (1 - n_o / 100) \cdot 10^{-3}$, kg/h (5.2)
where B – is the consumption of the applied materials, kg/h;

K^x_m – is the specific factor of the contaminant "x" per one unit of the consumable materials and row products, g/kg;

n_o – is the cinders formation owning to the electrode consumption standardized value, %.

When the technological tools are equipped with the local exhaust systems the quantity of the contaminants which are transferred into the environment through those systems will be equal to the quantity emitted pollutants multiplied by the local exhaust systems effectiveness value introduced in fraction of a unit.

The gross amount of the pollutants released during the welding materials consumption is determined by the following equation:

$M = B'' \cdot K^x_m \cdot (1 - n_o / 100) \cdot \eta \cdot 10^{-6}$, t/year (6.2)
where B'' - is the consumption of the row materials, kg/year;

η - is the local exhaust systems effectiveness in fraction of a unit.

The maximum one-time emission of the pollutants released during the welding process is determined by the following equation:

$G = 10^3 \cdot M_{bi} \cdot \eta / 3600$, g/s (7.2)

The calculation of the maximum annual one-time pollutant emission into the environment is introduced below.

B = 1 / 1 = 1 kg/h. (8.2)

123. Ferrum oxide

$M_{bi} = 1 \cdot 7,67 \cdot (1 - 15 / 100) \cdot 10^{-3} = 0,0065195$ kg/h;

$M = 617,5 \cdot 7,67 \cdot (1 - 15 / 100) \cdot 0,4 \cdot 10^{-6} = 0,0016103$ t/year;

$G = 10^3 \cdot 0,0065195 \cdot 0,4 / 3600 = 0,0007244$ g/s;

$C = 10^3 \cdot 0,0007244 \cdot 3600 \cdot 8 / 12 / 30 / 6 = 9,66$ mg/m^3.

Conclusion: calculated concentration is unacceptable in view of the ultimate limit concentrations of the harmful substances in the air which is equal to 6 mg/m^3. As a result the additional local ventilation must be organized in the working place.

143. Manganese and its compounds

$M_{bi} = 1 \cdot 1,9 \cdot (1 - 15 / 100) \cdot 10^{-3} = 0,001615$ kg/h;

$M = 617,5 \cdot 1,9 \cdot (1 - 15 / 100) \cdot 0,4 \cdot 10^{-6} = 0,0003989$ t/year;

$G = 10^3 \cdot 0,001615 \cdot 0,4 / 3600 = 0,0001794$ g/s.

$C = 10^3 \cdot 0,0001794 \cdot 3600 \cdot 8 / 12 / 30 / 6 = 2,39$ mg/m^3.

Conclusion: calculated concentration is unacceptable in view of the ultimate limit concentrations of the harmful substances in the air which is equal to 0,2 mg/m^3. As a result the additional local ventilation must be organized in the working place.

2908. Inorganic dust containing 70-20% SiO2

$M_{bi} = 1 \cdot 0,43 \cdot (1 - 15 / 100) \cdot 10^{-3} = 0,0003655$ kg/h;

$M = 617,5 \cdot 0,43 \cdot (1 - 15 / 100) \cdot 0,4 \cdot 10^{-6} = 0,0000903$ t/year;

$G = 10^3 \cdot 0,0003655 \cdot 0,4 / 3600 = 0,0000406$ g/s.

$C = 10^3 \cdot 0,0000406 \cdot 3600 \cdot 8 / 12 / 30 / 6 = 0,54$ mg/m^3.

Conclusion: calculated concentration is unacceptable in view of the ultimate limit concentrations of the harmful substances in the air which is equal to 0,3 mg/m^3. As a result the additional local ventilation must be organized in the working place.

Terra Joint area

The quality and quantity characteristics of the contaminants released into the atmosphere are introduced in the following table:

Contaminant		Maximum one-time release, g/s	Annual emission, t/year
Code	Name		
123	Ferrum oxide	0,0006451	0,0002322
143	Manganese and its compounds	0,0000992	0,0000357
164	Nickel oxide	0,0000963	0,0000347
203	Hexavalent chromium	0,0000756	0,0000272
301	Nitrogen dioxide (Nitrogen (IV) oxide)	0,0000812	0,0000292
304	Nitrogen (II) oxide	0,0000132	0,0000048
337	Carbon monoxide	0,0018535	0,0006673

Table 10.2. Characteristic contaminants released into the atmosphere.

Initial data for the pollutant emissions calculation are introduced in the table:

Name	Design parameter		
	Characteristic, designation	Unit	Value
1. Kempact Mig 2530. Semi automatic welding of the steel materials in the CO$_2$ environment by the use of the electrode wire.			
	Specific factor of the contaminant "x" per one unit of the consumable materials and row products, K^x_m:		
	123. Ferrum oxide	g/kg	6,83
	143. Manganese and its compounds	g/kg	1,05
	164. Nickel oxide	g/kg	1,02
	203. Hexavalent chromium	g/kg	0,8
	301. Nitrogen dioxide (Nitrogen (IV) oxide)	g/kg	0,344
	304. Nitrogen (II) oxide	g/kg	0,0559
	337. Carbon monoxide	g/kg	7,85
	Standardized value of the expenditure cinders	%	15

releasing from the electrodes, n_o		
Consumption of the welding materials during one year, B''	kg	100
Consumption of the welding materials during the intense work period, B'	kg	1
Intense work time, т	h	1
Local suction effectiveness, η in the fractions of the unit:		
123. Ferrum oxide	-	0,4
143. Manganese and its compounds	-	0,4
164. Nickel oxide	-	0,4
203. Hexavalent chromium	-	0,4
Simultaneity of the work	-	yes

Table 11.2. Initial data for the pollutant emissions calculation.

B = 1 / 1 = 1 kg/h.

   123. Ferrum oxide

M_{bi} = 1 · 6,83 · (1 - 15 / 100) · 10^{-3} = 0,0058055 kg/h;

M = 100 · 6,83 · (1 - 15 / 100) · 0,4 · 10^{-6} = 0,0002322 t/year;

G = 10^3 · 0,0058055 · 0,4 / 3600 = 0,0006451 g/s;

C = 10^3 · 0,0006451 · 3600 · 8 / 12 /30 / 6 = 8,601 mg/m^3.

Conclusion: calculated concentration is unacceptable in view of the ultimate limit concentrations of the harmful substances in the air which is equal to 6

mg/m^3. As a result the additional local ventilation must be organized in the working place.

143. Manganese and its compounds

M_{bi} = 1 · 1,05 · (1 - 15 / 100) · 10^{-3} = 0,0008925 kg/h;

M = 100 · 1,05 · (1 - 15 / 100) · 0,4 · 10^{-6} = 0,0000357 т/год;

G = 10^3 · 0,0008925 · 0,4 / 3600 = 0,0000992 g/s;

C = 10^3 · 0,0000992 · 3600 · 8 / 12 /30 / 6 = 1,32 mg/m^3.

Conclusion: calculated concentration is unacceptable in view of the ultimate limit concentrations of the harmful substances in the air which is equal to 0,2 mg/m^3. As a result the additional local ventilation must be organized in the working place.

164. Nickel oxide

M_{bi} = 1 · 1,02 · (1 - 15 / 100) · 10^{-3} = 0,000867 kg/h;

M = 100 · 1,02 · (1 - 15 / 100) · 0,4 · 10^{-6} = 0,0000347 t/year;

G = 10^3 · 0,000867 · 0,4 / 3600 = 0,0000963 g/s;

C = 10^3 · 0,0000963 · 3600 · 8 / 12 /30 / 6 = 1,284 mg/m^3.

Conclusion: calculated concentration is unacceptable in view of the ultimate limit concentrations of the harmful substances in the air which is equal to 0,01 mg/m^3. As a result the additional local ventilation must be organized in the working place.

203. Hexavalent chromium

M_{bi} = 1 · 0,8 · (1 - 15 / 100) · 10^{-3} = 0,00068 kg/h;

M = 100 · 0,8 · (1 - 15 / 100) · 0,4 · 10^{-6} = 0,0000272 t/year;

G = 10^3 · 0,00068 · 0,4 / 3600 = 0,0000756 g/s;

$C = 10^3 \cdot 0{,}0000756 \cdot 3600 \cdot 8 / 12 / 30 / 6 = 1{,}01$ mg/m^3.

Conclusion: calculated concentration is unacceptable in view of the ultimate limit concentrations of the harmful substances in the air which is equal to 0,0015 mg/m^3. As a result the additional local ventilation must be organized in the working place.

301. Nitrogen dioxide (Nitrogen (IV) oxide)

$M_{bi} = 1 \cdot 0{,}344 \cdot (1 - 15 / 100) \cdot 10^{-3} = 0{,}0002924$ kg/h;

$M = 100 \cdot 0{,}344 \cdot (1 - 15 / 100) \cdot 1 \cdot 10^{-6} = 0{,}0000292$ t/year;

$G = 10^3 \cdot 0{,}0002924 \cdot 1 / 3600 = 0{,}0000812$ g/s;

$C = 10^3 \cdot 0{,}0000812 \cdot 3600 \cdot 8 / 12 / 30 / 6 = 1{,}08$ mg/m^3.

Conclusion: calculated concentration is unacceptable in view of the ultimate limit concentrations of the harmful substances in the air which is equal to 0,085 mg/m^3. As a result the additional local ventilation must be organized in the working place.

304. Nitrogen (II) oxide

$M_{bi} = 1 \cdot 0{,}0559 \cdot (1 - 15 / 100) \cdot 10^{-3} = 0{,}0000475$ kg/h;

$M = 100 \cdot 0{,}0559 \cdot (1 - 15 / 100) \cdot 1 \cdot 10^{-6} = 0{,}0000048$ t/year;

$G = 10^3 \cdot 0{,}0000475 \cdot 1 / 3600 = 0{,}0000132$ g/s;

$C = 10^3 \cdot 0{,}0000132 \cdot 3600 \cdot 8 / 12 / 30 / 6 = 0{,}176$ mg/m^3.

Conclusion: calculated concentration is acceptable in view of the ultimate limit concentrations of the harmful substances in the air which is equal to 0,4 mg/m^3.

337. Carbon monoxide

$M_{bi} = 1 \cdot 7{,}85 \cdot (1 - 15 / 100) \cdot 10^{-3} = 0{,}0066725$ kg/h;

$M = 100 \cdot 7{,}85 \cdot (1 - 15 / 100) \cdot 1 \cdot 10^{-6} = 0{,}0006673$ t/year;

$G = 10^3 \cdot 0{,}0066725 \cdot 1 / 3600 = 0{,}0018535$ g/s;

$C = 10^3 \cdot 0{,}0018535 \cdot 3600 \cdot 8 / 12 / 30 / 6 = 24{,}71$ mg/m^3.

Conclusion: calculated concentration is unacceptable in view of the ultimate limit concentrations of the harmful substances in the air which is equal to 5 mg/m^3. As a result the additional local ventilation must be organized in the working place.

Welding area

The quality and quantity characteristics of the contaminants released into the atmosphere are introduced in the following table:

Contaminant		Maximum one-time release, g/s	Annual emission, t/year
Code	Name		
123	Ferrum oxide	0,0007244	0,0002608
143	Manganese and its compounds	0,0001794	0,0000646
2908	Inorganic dust containing 70-20% SiO2	0,0000406	0,0000146

Table 12.2. Characteristic contaminants released into the atmosphere.

Initial data for the pollutant emissions calculation are introduced in the table:

Name	Design parameter		
	Characteristic, designation	Unit	Value
-Kemppi ProMig Pro 4200. Semi automatic welding of the steel materials in the CO$_2$ environment by the use of the electrode wire.			
	Specific factor of the contaminant "x" per one unit of the consumable materials and row products, K^x_m:		
	123. Ferrum oxide	g/kg	7,67
	143. Manganese and its compounds	g/kg	1,9
	2908. Inorganic dust containing 70-20% SiO2	g/kg	0,43
	Standardized value of the expenditure cinders releasing from the electrodes, n_o	%	15
	Consumption of the welding materials during one year, B''	kg	100
	Consumption of the welding materials during the	kg	1

intense work period, B'		
Intense work time, т	h	1
Local suction effectiveness, η in the fractions of the unit:		
123. Ferrum oxide	-	0,4
143. Manganese and its compounds	-	0,4
2908. Inorganic dust containing 70-20% SiO2	-	0,4
Simultaneity of the work	-	yes

Table 13.2. Initial data for the pollutant emissions calculation.

B = 1 / 1 = 1 kg/h;

123. Ferrum oxide

$M_{bi} = 1 \cdot 7,67 \cdot (1 - 15 / 100) \cdot 10^{-3} = 0,0065195$ kg/h;

$M = 100 \cdot 7,67 \cdot (1 - 15 / 100) \cdot 0,4 \cdot 10^{-6} = 0,0002608$ t/year;

$G = 10^3 \cdot 0,0065195 \cdot 0,4 / 3600 = 0,0007244$ g/s;

$C = 10^3 \cdot 0,0007244 \cdot 3600 \cdot 8 / 12 / 30 / 6 = 9,66$ mg/m^3.

Conclusion: calculated concentration is unacceptable in view of the ultimate limit concentrations of the harmful substances in the air which is equal to 6 mg/m^3. As a result the additional local ventilation must be organized in the working place.

143. Manganese and its compounds

$M_{bi} = 1 \cdot 1,9 \cdot (1 - 15 / 100) \cdot 10^{-3} = 0,001615$ kg/h;

$M = 100 \cdot 1,9 \cdot (1 - 15 / 100) \cdot 0,4 \cdot 10^{-6} = 0,0000646$ t/year;

$G = 10^3 \cdot 0,001615 \cdot 0,4 / 3600 = 0,0001794$ g/s;

$C = 10^3 \cdot 0,0001794 \cdot 3600 \cdot 8 / 12 / 30 / 6 = 2,392$ mg/m^3.

Conclusion: The calculated concentration is unacceptable in view of the ultimate limit concentrations of the harmful substances in the air which is equal to 0,2 mg/m^3. As a result the additional local ventilation must be organized in the working place.

2908. Inorganic dust containing 70-20% SiO2

$M_{bi} = 1 \cdot 0,43 \cdot (1 - 15 / 100) \cdot 10^{-3} = 0,0003655$ kg/h;

$M = 100 \cdot 0,43 \cdot (1 - 15 / 100) \cdot 0,4 \cdot 10^{-6} = 0,0000146$ t/year;

$G = 10^3 \cdot 0,0003655 \cdot 0,4 / 3600 = 0,0000406$ g/s;

$C = 10^3 \cdot 0,0000406 \cdot 3600 \cdot 8 / 12 / 30 / 6 = 0,54$ mg/m^3.

Conclusion: calculated concentration is unacceptable in view of the ultimate limit concentrations of the harmful substances in the air which is equal to 0,3 mg/m^3. As a result the additional local ventilation must be organized in the working place.

In accordance with the obtained results the measures which have to prevent the negative effect of the released substances are to be taken.

First of all the protection items are to be provided to all workers in accordance with GOST 12.4.011. These protection items differ in view of their way of use. They can be personal (PPI) or collective protection items (CPI). The CPI are classified depending on the harmful and dangerous factors (protection items against the noise, vibration, dust, etc) while the PPI are classified depending on the worker protected organs (protection items for the eyes, hands, body etc). These measures are applied when operation of the production process is impossible without releasing the harmful substances.

2.9 METHODS OF THE MICROCLIMATE PARAMETERS CONTROL

The laboratory methods are applied to estimate the gas contamination of indoor air. These methods imply the collection of the air samples during the production

process for the following analysis in the laboratory. For the rapid determination of the gas contamination level the express method with the use of the universal gas analyzers is applied. These analyses are based on the color reactions in the small volumes of the indicator substances. The indicator substance is put into the glass tube (indicator tube) through which the analyzed air is sucked by means of the gas analyzer. The length of the colored column in the indicator tube informs about the hazards quantity. The hazards concentration is determined by comparing the colored column with the specially graduated scale (express method).

The main method of the dust concentration estimation in the air is the weight method which is based on the dusty air sucking through the analytical filters. The efficiency of the dust retention is 99.5%.

2.10 CLASSIFICATION OF THE VENTILATION SYSTEMS

In view of the way of the air transmittance the ventilation system can be natural or mechanical.
The natural ventilation system is provided by the difference between the indoor and outdoor air temperatures or the wind action. The natural ventilation system can be organized or irregular. The most common type of organized ventilation is aeration. (SNiP II-4-79)
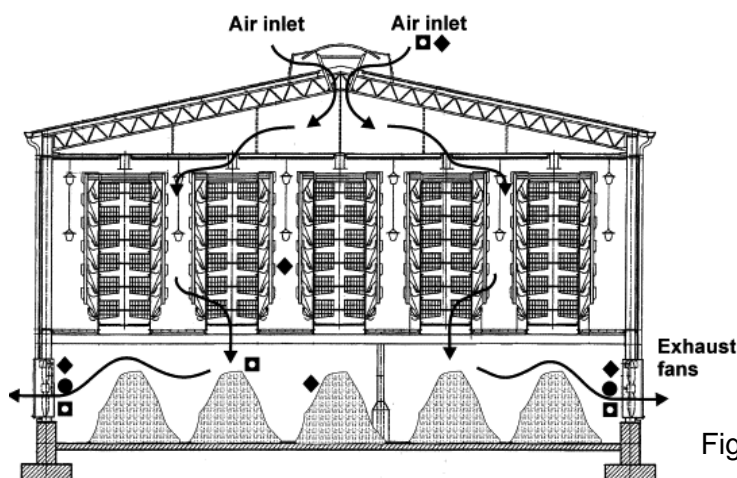

Figure 10.2. Natural ventilation scheme

In case of irregular ventilation system the air exchange is provided by the displacement of the hot air through the doors and windows by the outdoor cold air movement.

The natural ventilation system is economical, easy in use but has significant disadvantages: it is applied in case of releasing small volumes of fumes; the supplied air is not heated, not humidified and not cleaned from the contaminants.

2.11 MECHANICAL VENTILATION

The mechanical ventilation serves to eliminate the natural ventilation system disadvantages. In case of mechanical ventilation the air exchange is achieved by means of pressure which is provided by the centrifugal or axial ventilator.

Mechanical ventilation provides the supplied air jam from those places where it is the cleanest. The heating, moistening or subdrying of air with its transmittance to the working places or equipment is possible moreover its removal with the cleaning from the different places is applicable. The mechanical ventilation system can be executed in the form of stitched, exhaust of forced air and exhaust ventilation systems. During the air exchange accountancy, ventilators are chosen from the special catalogs according to the air consumption L and the general hydraulic resistance of the ventilation system H.

$H = P_{pot} + P_{sk} + P_k + P_f$, Pa (9.2)

where P_{pot} — is the total losses in ventilation network, they consist of the air friction pressure losses and in angles and other geometric forms of air piping system;

P_{sk}— is the dynamic pressure in the air escape section;

P_k— pressure losses in the heater;

P_f— pressure losses in the filter.

Ventilator's power consumption N_{ven}, kW is determined by the following equation:

$$N_{ven} = \frac{LH}{102 \eta_{ven} \cdot 3600}, \ (10.2)$$

where ŋ — is the efficiency factor of the ventilator chosen from the catalog, equal to 0,5…0,85.

Moreover, air-conditioning, air showers, and local ventilation systems are applied in production.

2.12 LIGHTING AND ILLUMINATION ON THE FACTORY

- The designed illumination equipment must provide:

- Standardized value of the CNL (coefficient of the nature light) and the lightness on the working places and in the escapes between the working equipment in case of the operating and the emergency conditions;

- Regulated values of the lightning installations quality indicators : - glare P and total discomfort M indicators, Ripple light coefficient Kp, and the requirements for the equitability of the distribution CNL and the light inside the operating zones of the premise;

- Regulated value of the safety factor.

In the content of the light projects the arrangements providing the possibility of the sensible installation and exploitation of the light installations must be taken into account:

- In accordance with the Orderer Approval in the estimating documentation the movable arrangements and equipment which enable to access to the light apertures and the lighting installations or the relevant documentation for the preparation such kind of arrangements is made and the further organizations are to be completed by means of the Orderer sources are taken in to account;

- Constructors are given the documentation with the task for the installation of the sensible arrangements for the light apertures and the lighting installations service (if it is needed);

- Constructors are given the documentation with the task for the installation of the workroom for the repairing and cleaning of the lighting installations;

- The number of the operational staff is calculated;

- Lighting control schemes are developed for the energy saving which enable the possibility of the full or partly work of the lighting installations depending on of the daytime and the working process;

- The relevant measures are designed to avoid the surge in the lighting installations;

- Constructors are given the documentation with the task for the installation different of light apertures, eavesdropping details and the components for the construction of the lighting circuits, electrical equipment fixtures and the constructional drawings for the installation of the lamps and other lighting equipment.

In case of developing indoor and outdoor lighting projects it is recommended to make several calculations with the use of different variants of the initial data to find out the most effective and suitable variant, which must meet the requirements of the regulation norms.

In accordance with SNiP II-4-79 the total area of the country is divided into five zones of the country light climate. Following the list of those zones and the areas which belong to these zones may be concluded that the St. Petersburg area belongs to the II zone of the light climate.

In case of the nature light; lateral illumination and inside the production premises the standardized value of the CNL depends on the type of the visual work.

In the Peikko's production process the type of the visual work may be corresponded to the VI, V and VII.

The orientation of the light apertures to the cardinal points in degrees is equal to the following:

136-225; 226-315 and 46-135; 316-45

Considering the orientation of the light apertures to the cardinal points and the type of the visual works the CML is equal to the following dimensions:

	CNL value,%		
	IV	V	VII
136-225	1,4	0,9	0,9
226-315	1,5	1,0	1
and 46-135 316-45	1,6	1,1	1,1

Table 14.2. CML values.

The standardized values of the CNL depend on:

- the standardized values of the illumination from the artificial light in case of different types of the visual works depending on the critical outdoor illuminations using the following equation:

$E_H = 0,01 e E_{cr}$, (11.2)

where e – is the coefficient nature lighting ; E_{cr} – is the critical outdoor illumination.

- the smallest dimension of the object which must be admitted during the work process, the type of the visual work; the object discrimination contrast with the background, the background characteristics;

- building location on the light climate map;

- the standardized value of the CNL considering the type of the visual work and the light climate features of the building location;

- the required natural light uniformity;

- the dimensions and location of the equipment, their possible shading of the work surfaces;

- the preferable direction of the lighting flow falling on the working surface;

- the duration of the natural light use for one day of the different seasons considering the premise purpose, the work schedule and the light climate of the location;

- the necessity of the premise protection from the glare effect of the direct sunlight.

It is recommended to make the design of the natural light of the buildings in the following sequence:

- the 1st stage – determination of the requirements to the natural lighting of the premises; determination of the standardized value of the CNL in accordance with the most common type of the visual work for the production process;

- choice of the lighting systems;

- choice of the types of the light apertures and the translucent material;

- choice of the arrangements for the limitation of the sunlight glares effect;

- taking into consideration the building orientation;

- the 2nd stage – making preliminary calculation of the natural lighting of the premises (determination of the necessary area of the light apertures);

- checking of the light apertures and premises parameters;

- the 3rd stage – making checking calculation of the natural lighting of the premises;

- determination of the premises, zones and areas which have lack of natural lighting in view of the standards and norms;

- determination of the requirements to the additional artificial lighting of the premises, zones and areas which have lack of natural lighting in view of the standards and norms;

- determination of the requirements to the exploitation of the light apertures;

- the 4[th] stage – making all necessary adjustments to the total natural light project (if it is needed).

Natural lighting system of the premises (side, top or combined) is recommended if the following factors are considered:

- the purpose of the building; its architectural and construction type;

- the requirements to the natural lighting of the premises in accordance with the special features of the technology and the character of the visual work;

- climatic and light features of the climate of the construction area;

- profitability of the natural lighting.

The top and combined natural lighting must be arranged in most cases in the production single storey multispan.

The side natural lighting must be arranged in a multi-storey production building.

In case of the side natural lighting design it is better to apply the standardized window structures which are introduced in the following table.

In the Peikko's production building the standardized window structure with the steel sashes which are made of single rectangular steel pipes and opening mechanism (1.436.2-17 series). Coordination windows size in this case is equal:

height = 1.2 m;

width = 0.8 m.

GOST 12506-81 recommends to use the windows with the wooden sashes in the production buildings.

The structures of the windows with the single or double glazing must be chosen depending on the inside and outside air temperature difference in accordance with SNiP II-3-79. In case of the multi-tiered set of windows in accordance with the series: 17436.2-15, 1.436.2-17 and GOST 12506-81 the total height of the glazing must not exceed 7.2 m; and the 1.436.3-16 series – 6 m.

In case of side natural lighting inside the production building the window height must be calculated according to the premises depth and the accuracy of the operated works. Moreover in case the premises height is equal or less than 7.2 m it is sensible to possess the windows in one tier.

The quantity of the glazing layers inside the windows is taken in accordance with the requirements of SNiP II-3-79;

In accordance with the Manual to SNiP II-4-79 inside the premises the height of which is equal to 6 m and the width is 12 m the windows with the aluminum alloys sashes.

For the preliminary calculation of the light apertures dimensions in case of the side lighting the following chart must be applied.

When the dimensions and positions of the light apertures were chosen in accordance with the architectural and constructional requirements the preliminary calculation of the CNL values in premises with the side natural lighting must be made in accordance with the following picture.

The CNL values are determined in the following sequence:

a) by the use of the constructional drawings the total area of all light apertures A_o and the illuminated premises floor area A_f and then the A_o/A_f ratio is determined:

$A_o = 1.2 \cdot 0.8 \cdot 6 \cdot 4 = 23.04$ m^2;

$A_f = 30 \cdot 12 = 360$ m^2;

$$A_o/A_f = \frac{23.04}{360} = 0.064.$$

b) the depth of the premises d_p and the height of the upper edge of the light apertures above the working surface level h_{01} are determined and then the ratio d_p/h_{01} is calculated:

$d_p = 12$ m;

$h_{01} = 4.2$ m;

$$d_p/h_{01} = \frac{12}{4.2} = 2.85.$$

c) considering the values of $A_o/A_п$ and $d_п/h_{01}$ the point with the corresponding value of e is determined using the chart.
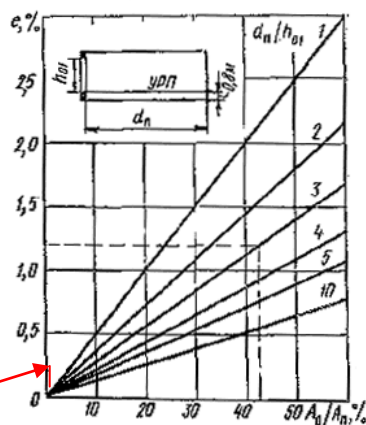

Figure 11.2. Chart for the determination of the CNL value in case of the industrial building side natural lighting.

e=0.005

The result of the NCL is unsatisfactory. As a result it is sensible to apply the combined lighting.

The standardized values of the CNL for the Peikko's production building in case of the combined illumination are introduced in the following table:

Orientation of the light apertures towards the horizon, degrees	CNL, %, in accordance with the type of the visual work		
	IV	V	VII
136-225	0,8	0,6	0,6
226-315 and 46-135	0,9	0,6	0,6
316-45	1,0	0,7	0,7

Table 15.2. Standardized values of the CNL.

Windows fill type is the double glazing (two layers of glass) in the single steel opening sashes owning that the value of the coefficient K_1 is equal to 1.

The combined lighting of the production buildings premises is recommended to apply in the following cases:

a) in case of the technical and economic advances compared with the natural lighting;

b) in those kind of premises where the visual work of the accuracy type I or II is performed;

c) when the chosen space and planning solutions of the building from point of view of the technology conditions and the production organization does not provide the efficient level of the natural lighting in accordance with the standards and norms;

d) in case of the building construction in the climate zones with the severe climatic conditions in which it is adopted to reduce the total area of the light apertures till the minimum value with the purpose to decrease the heat loss;

e) in the factories with the oversized equipment which caused the shading of the natural lighting;

f) In case of an increase of the requirements to the intensity, quality and constancy of the lighting on those working places which cannot be satisfied by the natural lighting;

g) when the premises with the big depth and the side illumination of the production buildings are considered in view of the rational space planning solution of the building.

2.13 METHODS OF THE LIGHTING CALCULATION

The method of the luminous flux (the method of the utilization coefficient) is the main one for the total uniform illumination calculation for the production

premises when the average illumination of the horizontal surface is determined.

The lighting flow of the group of lamps F_l in case of the fluorescent lamps is determined using the following equation:

$$F_l = \frac{E_N S K Z}{N \eta}, (12.2)$$

where E_N — standardized minimal lighting of the working place, Lk is given in SNB 2.04.05-98 in accordance with the relevant type of the visual work:

Type of the visual work	E_N, Lk	Blinding factor, P	Ripple factor, K_r, %
VI	200	40	20
V	300	40	20
VII	200	40	20

Table 16.2. Standardized minimal lighting of the working place

S — is the area of the lighting premise, m^2: S = 360 m^2

K — is the safety factor which is determined in accordance with SNB 2.04.05-98: K = 1.5;

Z — is the minimal illumination factor which is equal to 1,1 for the fluorescent lamps;

N — is the quantity of the lamps in the premise;

η — is the coefficient of the lamps lighting flow use and is depending on the efficiency and the lamps light power distribution curve, lighting flow reflectance factors form the ceiling ρ_{pot}, walls ρ_{ct} and from the working surface ρ_r factors, the height of the lamps suspension and the premise dimensions.

The η value can be represented in the following form:

$\eta = \eta_{st} \eta_P$, (12.2)

where η_{st} — is the lamp efficiency factor which is determined by the use of the main lamps parameters table;

η_p — is the indicator of the illuminated premise.

The value of the η_p is determined in dependence on the lighting flow reflectance form the ceiling ρ_{pot}, walls ρ_{st} and from the working surface ρ_p factors, lamps lighting power curves (KSS) and the premise index I, which is determined using the following ratio:

$$i = \frac{AB}{H_p(A+B)} ; (13.2)$$

where A — is the length of the premise, m;

B — is the width of the premise, m;

H_p — is the designed height of the lamp suspension above the working surface, m.

$$H_p = h - H_0, (14.2)$$

where h — is the height of the lamp suspension, m;

H_0 — is the height of the working surface, m.

H_p = 6 - 1.2 = 4.8 m

$$i = \frac{30 \cdot 12}{4.8 \cdot (30 + 12)} = 1.786$$

The lighting flow reflectance form the ceiling, walls and from the working surface factors are given in table 19, SNB 2.04.05-983, in dependence on the using materials.

In case of the Peikko's production premise the average values of this factors is equal 50, 30, 10% for the walls, ceiling and floor correspondingly .

The safety factor for the using type of the lamps is equal to 1.5.
The required number of the lamps is determined by the following way. The distance between the centers of the lamps:
L= $H_p \cdot$m, m, (15.2)
where m — is the most advantageous ratio for the premise . L value is recommended to take equally to 5…6 m for the production premises. The value is determined and in accordance with its result the lamp classification

curve is determined. Using the lamps main parameters table the lamp and the relevant efficiency factor is determined.

L= 4.8·5 = 24 m

The distance from the premise walls to the first lamps row in case of the presence of the working places near with the walls, is equal to the following:

$a = \frac{1}{3}L$, in case of the absence of the working places - $a = \frac{1}{2L}$.

$a = \frac{1}{3} \cdot 24 = 8$ m; $a = \frac{1}{2 \cdot 24} = 0.021$ m

The distance between the outermost lamp rows which are located near the opposite walls is equal to: in the premise width direction $C_1 = B - 2a$; in the premise length direction $C_2 = A - 2a$.
$C_1 = 12 - 2 \cdot 0.021 = 11.958$ m; $C_2 = 30 - 2 \cdot 0.021 = 29.958$ m

As a result the quantity of the lamps rows, which can be located between the outermost rows is equal: in the width direction - $n_1 = \frac{C_1}{L} - 1$; in the length direction - $n_2 = \frac{C_2}{L} - 1$.

$n_1 = \frac{C_1}{L} - 1 = \frac{11.958}{24} - 1 = |0.5|$; $n_2 = \frac{C_2}{L} - 1 = \frac{29.958}{24} - 1 = 0.25$

The total quantity of the lamps rows: in the width direction - $K_1 = n_1 + 2$; in the length direction - $K_2 = n_2 + 2$.

$K_1 = 0.5 + 2 = 2.5 \approx 3$; $K_2 = 02.5 + 2 = 2.25 \approx 2$

The total quantity of the lamps is equal to: $N = K_1 K_2$.

$N = 3 \cdot 2 = 6$

After the Fл determination, the nearest standardized lamp is chosen and the electrical capacity of the whole lighting system is determined. Practically the difference between the designed value of the lamp lighting flow and the chosen value should not exceed 20% otherwise the other system of the lamps location must be chosen.

The choice of the light sources and the lighting equipment are to be made on the basis of the reference books.

In accordance with the results of the calculation the DRL125 Lamps are recommended with the lighting flow equal to 5600lm.

2.14 LIGHTING CONTROL IN THE PRODUCTION PREMISES

For the determination of the quantity and quality indicators of the production lighting photometers, light meters and the visibility meters are used.

The light meter U-116 consists of the measuring instrument, photoelectric sensor and the nozzles package. This instrument allows to measure the illumination till 100 000 Lk.

The lighting control is produced during the darkest season after the lamp cleaning. (SNiP, 23-05-95)

Illumination measurement in the reference point is produced in the following sequence.
The photoelectric sensor is connected to the device-meter the hypersensitive element is possessed parallel to the working surface. The scale of the light meter pointer is chosen by pressing the relevant buttons. If the pointer rolls over (it means that the illumination value exceeds the grading scale) it is necessary to extend the range of the measurements by the use of one of the nozzles. The result of the measurements is to be multiplied by the conversion factor which is stated on the nozzle.
Nowadays the wide range of other equipment which is suitable for such kind of measurements is applicable.

2.15 NOISE SOURCES AND NOISE INDICATORS

Some manufacturing processes are accompanied by the industrial noise.
The intense noise sources are the machines with the unbalanced rotating

masses in certain kinematic pairs from which the friction and the collisions arise. Moreover some plant equipment in which the fluid and gas movement leads at a high speed and is accompanied by a surge. This type of the noise sources in the work place include various crushers, mills, blowers, air ventilation system, electric motors, pumps, presses, punching machines, etc.

The main sources of the industrial noise are the metalworking, woodworking, power and ventilation systems, internal transport, etc.

The noise is considered as the totality of the different sounds in view of their strength and frequency that occur owning to the vibrational particulars motion in the elastic environments. The noise is produced by the mechanical vibration in the solids, liquids and gases. The mechanical vibrations in the frequency range 16…20000 Hz are perceived by the human auditory organ in the form of sound. The oscillations below 16 Hz (infrasound) and above 20 000 Hz (ultrasound) do not cause any auditory feelings, but affect human organism biologically.

The sound is characterized by the frequency f, intensity I and sound pressure P. The speed of the sound waves propagation in the air when the temperature t=20 °C is equal to 343 m/s, in steel 500 m/s, in concrete 4000 m/s. The part of the space where the sound waves propagate is called sound field.

In case of the environment vibrations its elementary particulars fluctuate relatively its initial position. During the oscillations the areas of the low pressure and the high pressure which determine the sound pressure value as the difference between the perturbed and the unperturbed air arise in the air.

The human hearing aid has different sensitivity to the sound of different frequency. The minimum sound pressure and the minimum intensity of the sounds which are perceived by the human ear determine the threshold of the audibility. (SN 3223-85, 12.03.85)

For the reference adopted sound with the 1000Hz frequency. At this frequency the threshold of the audibility by the intensity is equal to the following:

$I_0 = 10^{-12}$ W/m^2 and its corresponding sound pressure is: $P_0 = 2 \cdot 10^{-5}$ Pa. The upper limit of the sound perceived by the human is treated as so called the pain threshold. The pain threshold is 120-130dB. At a frequency of 1000Hz the pain

threshold arises in the following conditions: I = 10 W/m^2 and P$_0$ = 2 · 10^2 Pa. Between the hearing threshold and the pain threshold is the area of hearing (auditory).

2.16 NOISE CLASSIFICATION AND THEIR CHARACTERISTICS

A human is able to perceive the sounds in the great range of the intensities. As a result it is absolutely unsuitable to use the absolute value of the sound intensity and the sound pressure. In the acoustics it is common to measure not absolute values of the sound intensity but their relative logarithmic levels which are taken in relation to the threshold value I$_0$ or P$_0$.

The human hearing organ is capable of distinguishing of the sound growth by 1dB which is adopted in the acoustic measurements practice as the basic unit.

In practice two logarithmic values are used for the noise characteristic: the level of the intensity L and the level of the sound pressure L_p dB. (SN 3223-85, 12.03.85)

$$L = 10 \log \frac{I}{I_0}, \text{ dB, (15.2)}$$

$$L_p = 20 \log \frac{P}{P_0}, \text{ dB, (16.2)}$$

where I — is the sound intensity in the reference point, W/m^2;

I$_0$ — is the sound intensity which corresponds to the threshold of hearing at a frequency equal to 1000 Hz;

P — is the sound pressure in the reference point, Pa;

$P_0 = 2 \cdot 10^{-5}$ Pa — is the threshold sound pressure at a frequency equal to 1000 Hz.

The logarithmic scale in decibels (0…140) allows to determine a physical noise characteristic regardless of frequency. The highest sensitivity of the human hearing organ is typical for the middle and high frequencies (800-1000 Hz) and

the lowest sensitivity is typical for the low frequencies (20-100 Hz). Therefore in order to make the results of the objective measurement closer to the subjective perception the concept of the corrected sound pressure level is composed. The essence of the correction is taking into account the corrections to the level of the corresponding value depending on the sound frequencies. These corrections are standardized in the international scale. A correction is most commonly used. The corrected level of the sound pressure $L_a = L_p + CL_a$ is called the sound level and is measured in dBA.

During the noises research the whole range of the frequencies is divided into the frequency stripes and then the process capacity is determined which goes through each stripe. Most commonly the active and the third active frequency stripes are used. The center frequency (f) characterizes the stripe totally.

$$f = \sqrt{f_1 f_2}, \ (17.2)$$

where f_1 and f_2 — is the high and low boundary frequencies of the octave band noise.

Thus the row of the 9 active bands was formed with the geometrical mean frequencies: 31,5; 63; 125; 250; 500; 1000; 2000; 4000; 8000 Hz, which are used in GOST 12.1.003-83.

In accordance with GOST 12.1.003-83 and SN 9-86 RB98 the ultimate noise levels are classified:

- relatively to the nature of the spectrum: broadband with the continuous spectrum of more than one octave; tonal – in the spectrum of which the discrete tones are and for the practical purposes (in case of the sound parameters on the working place) the tonal character is established by the measurement in the third of the octave band frequencies by the exceeding of the sound pressure in the one band comparatively to the adjacent not less than on 10 dB;
- in accordance with the temporal characteristics by: continuous (its sound level may differ during the 8 hours' work day not more than on 5 dBA;

49

- inconstant sound level of which during the 8 hours' work day differs more than on 5 dBA.

Inconstant noise is subdivided into:

- fluctuating in time (the sound level of which is constantly changing during the time);
- intermittent sound level of which is changed stepwise by 5 dBA and more in case of the interval length during which the noise is constant is equal to 1 s and more;
- pulsed which consists of one or several sound signals each of which lasts less than 1 s.

2.17 NOISE EFFECT ON THE HUMAN

From the physiological point of view the noise is considered as unpleasant for the perception sound process, which interferes the conversation and affects the human health. During the prolong noise impact the hearing acuity is reduced, the blood pressure is changed, the attention is weakened, the vision comes poor etc. Intensive noise causes the functional changes of the cardiovascular system, the disruption of the normal function of the stomach and a wide range of other functional disorders in the human organism. (SN 3223-85, 12.03.85) Especially the noise impacts negatively on nervous and cardiovascular systems. Noise causes headaches, impairs the memory, slows down the mental reaction, becomes a reason of the nervous system break down, reduces the efficiency and productivity etc.

The intense noise leads to the propagation of the ear diseases.
The list of the changes that occur in the human organism during the long-term noise impact must be considered as the "noise disease".

2.18 NOISE STANDARDIZATION

In order to reduce the harmful noise impact on the working places rationing is introduced. The normalized parameters of the constant noise on the working places are:

- sound pressure levels L_p in the octave bands with the center frequencies 31.5; 63; 125; 250; 500; 1000; 2000; 4000; 8000 Hz are determined by the following equation:

$$L_p = 20 \log \frac{P}{P_0}, \text{ dB, (18.2)}$$

where P — is the average quadratic value of the sound pressure , Pa;

$P_0 = 2 \cdot 10^{-5} \text{Pa}$ — is the original value of the sound pressure in the air.

- sound level L_a dBA which is determined by the use of the following equation:

$$L_a = 20 \log \frac{P_a}{P_0}, \text{ dBA, (19.2)}$$

where P_a — is the average quadratic value of the sound pressure including the A correction of the noise meter, Pa.

Standardized parameters of the inconstant noise on the working places are:

- the equivalent (by the energy) sound level, dBA which is determined by the use of the following equation:

$$L_a = 10 \log \frac{1}{t} \oint (\frac{P_{at}}{P_0})^2 \cdot dt, \text{ (20.2)}$$

where P_{at} — is the current value of the mean square sound pressure including the A correction of the noise meter, Pa;

P_0 - is the initial value of the sound pressure in the air which is equal to $2 \cdot 10^{-5}$ Pa;

t - is the period of the noise action, hours;

The maximum sound level: for the oscillating in time and for the intermittent noise in dBA and for intense noise dBAI.

The assessment of the intermittent noise is the point of the ultimate limit levels must be provided both by the equivalent sound level and by maximum sound level, dBA and dBAi correspondingly.

The ultimate limit noise levels must be taken in accordance with GOST 12.1.003-83 and SN 9-86 RB98:

- for the tonal noise the noise levels must be taken less by 5 dB (dBA) then standardized values;
- for the generated by the indoor air conditioning systems noise the value must be taken less than those designed or calculated values if they are less than the standardized values the correction for the tonal and pulse noise is not considered and in all other cases it is considered by 5 dB less than standardized values.

The maximum sound level for the oscillating and intermittent noise should not exceed 110 dBA and for the pulse noise should not exceed 125 dBAI.

2.19 METHODS OF PROTECTION AGAINST NOISE

The development of the measures to prevent the noise negative factors must be started from the consideration of the possible ways of the noise weakness in the sources of its occurrence. Significant noise reduction can be achieved by the high quality installation of the machine's individual components, its dynamic balancing and conducting the timely repairing. (SN 3223-85, 12.03.85) Violation of the operating rules of the machines may lead to the intensive noise generating by the low-noise equipment. The capability of the building materials to dissipate the sound waves energy is used for the sound absorption. In case of the sound waves falling on the sound absorbing surface which is made of porous material the significant part of the acoustic energy is spent on making the air to vibrate inside the narrow

52

channels, pores. In this case the kinetic energy of the sound waves is converted into heat energy which then spreads in the environment. The most intense sound energy is converted by the porous and friable materials which are applied for the better sound absorption effect. The sound waves when they get in touch with the barrier may partially reflect or partially refract. The part of the refracted energy is absorbed by the barrier material. The rest of the sound energy penetrates beyond the barrier. (SN 3223-85, 12.03.85)
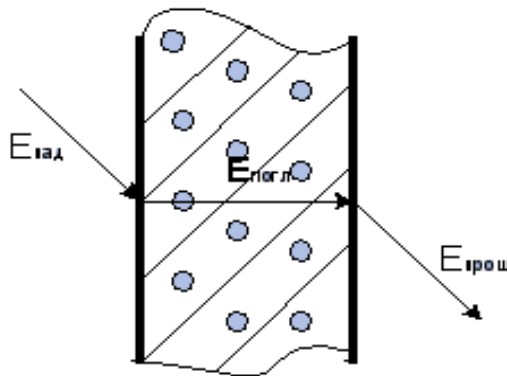
Figure 12.2. Scheme of the sound energy conversion.

The material's ability to absorb the sound energy is characterized by the sound absorption factor α which is equal to the ratio of the sound energy absorbed by the material E_{pog} to the incident sound energy E_{pad}.

$$\alpha = \frac{E_{pog}}{E_{pad}} < 1, \ (21.2)$$

The sound reflection form the barrier is characterized by the reflection factor β which is equal to the ratio of the reflected from the surface energy E_{otr} to the falling sound energy:

$$\beta = \frac{E_{otr}}{E_{pad}} < 1, \ (22.2)$$

The sound conductivity of the barrier is characterized by the sound conduction factor τ:

$$\tau = \frac{E_{prop}}{E_{pad}} , \ (23.2)$$

On the basis of the energy conservation theory:

$$\alpha + \beta + \tau = 1 \ , \ (24.2)$$

The strongest sound absorbing features have the fibrous and porous materials:

53

fibrolitovye plates, fiberglass, mineral wool, polyurethane cellular plastic, polyvinyl chloride and other porous sound-absorbing materials which have the sound absorbing factor more than 0.2.

The reduction value of the noise level in case of using the sound absorbing coating does not exceed at the general noise level 8dB and at the single active bands – 12-15 dB.

The noise can be reduced by the installation of the sound proof enclosures in the path of the obstacles.

The sound insulation features of the envelope and fencing are determined by the sound conduction factor t. For the diffusion sound field the insulation coefficient value R is determined using the following equation:

$R = 10 \log \frac{1}{\tau}$, dB, (25.2)

The sound insulating ability of the reflection depends on the material acoustic features, geometrical dimensions, mass, the number of the material layers, material elasticity, natural frequency of the envelope and the frequency characteristics of the noise.

In those cases when the sound reduction till ultimate limit values cannot be achieved by the technical measures for the workers safety the personal safety equipment is applied. As a personal safety equipment against noise the headphones, the earbuds, the helmets etc. are applied. The requirements to the design and the execution are described in the GOST 12.1.029-80 SSTB. The headphones protect the ears from the outside. The earbuds cover the ear channel. The helmets cover the part of the head and the ears. The noise protection suits provide the workers body safety. The main requirements to the noise protection suits are established in the GOST 12.4.051-78 SSTB.

2.20 CONTROL OF THE NOISE PARAMETERS

The measurement equipment is based on the electrical measuring methods. The converting of the mechanical vibrations is provided in the magneto-electric or in the piezo-electric receivers/transmitters. The electrical signals

which are received from the sensors amplify and then convert and are fed to the recording device which is scaled in the absolute and relative units.

For the noise measurement the noise meters are applied. The basic elements of the noise meter are: the microphone that converts sound waves of the environment into the electrical, the power, the rectifier and the dial gauge scaled in decibels. The noise meters has the correcting frequency characteristics.

2.21 INDUSTRIAL VIBRATION

Vibration is the mechanical oscillations and the waves in the solids.
Depending on the method of the transmission to human the vibration is divided into the local and general.

The local vibration is transmitted through the human hands; it affects the legs of the sitting human, the forearm which are in contact with the vibrating surfaces.
The overall vibration is transmitted through the bearing surfaces to the body of the sitting or staying human.
The sources of the local vibration which is transmitted to the workers can be: the manual machines with the engine or with the manual power tool; the equipment for the machines' maintenance; the hand tools and the work pieces. (SN 30043-84, 15.07.84)

The overall vibration in dependence on the source of its occurrence is divided into the following:

- the general vibration of the 1st category – transport vibration which affects the human on the working place in the self-propelled and towed vehicles, tin case of the vehicle driving on the terrain, roads;

- the overall vibration of the 2nd type – which affects the human on the working place in the machines which are transported by the use of special surfaces, areas of the production premise;

- the overall vibration of the 3rd type – technological vibration which affects the human on the working place transmitted by the stationary machines.

The overall vibration of the 3rd type in accordance with the action area is divided into the following types:

3a — on the permanent working places of the factories production premises;

3b — on the working places in the storages, canteens, controlling rooms and in the others subsidiary premises where there are no machines which generate the vibration;

3c — on the working places in the administrative offices of the production premise, design offices, laboratories, teaching points, data centers, health centers and other premises for the offices and knowledge workers. (SN 30043-84, 15.07.84)

In dependence on the time characteristics the vibration is divided into the following:

- the constant vibration, for which the spectrum or corrected by the frequency standardized parameter during the observation time (not less than 10 min or the technological cycle) differs not more than by two times (6 dB);

- the inconstant vibration for which the spectrum or corrected by the frequency standardized parameter during the observation time (not less than 10 min or the technological cycle) differs more than by two times (6 dB).

The main parameters which characterize the vibration are the following: frequency f Hz; amplitude A m; vibration velocity U m/s; vibration acceleration a m/s^2, the levels of the vibration velocity L_v and the vibration acceleration L_a dBa which are determined correspondingly by the following equations:

$V = 2\pi F A$ m/s; $a = (2\pi f)^2 A$ m/s, (26.2)

$L_v = 20 \log \dfrac{V}{V_0}$ dB; $L_a = 20 \log \dfrac{a}{a_0}$ dB, (27.2)

where V — is the average square value of the vibration velocity m/s;

V_0 — is the threshold vibration velocity value which is equal to $5 \cdot 10^{-8}$ m/s;

a — is the vibration acceleration m/s^2;

a_0 — is the threshold vibration acceleration value which is equal to $3 \cdot 10^{-4}$ m/s.

The level of the harmful impact of the vibration on the human organism depends on the vibration velocity at the oscillations' frequency equally more than to 10 Hz and from the vibration acceleration at the oscillations' frequency equally less than to 10 Hz.

The longitudinal impact of the intense vibration on the workers causes the special vibration disease which is connected with the weaknesses of the human initial organs.

In accordance with GOST 12.1.012-90, SN 9-90 RB 98 and SN 9-89 RB 98 the hygienic assessment of the permanent and non-permanent vibration is produced by the following methods:

- the frequency (spectral) analysis of the design parameter;
- the integrated assessment including the period of the vibration action by the equivalent (be the energy) level of the standardized parameter.

The main method is the frequency analysis. The normalized frequency range for the local vibration is established in the form of the octave bands with the center frequencies: 8; 16; 31,5; 125; 250; 500; 1000 Hz.

The normalized frequency range for the general vibration in dependence on the vibration category is stipulated in the form of the octave or third octave bands with the center frequency: 0,8; 1,0; 1,25; 1,6; 2,0; 2,5; 3,15; 4,0; 5,0; 6,3; 8,0; 10; 12,5; 16,0; 20,0; 25,0; 31,5; 40,0; 50,0; 63,0; 80,0 Hz (for the 3a category — 2,0; 4,0; 8,0; 16,0; 31,5; 63,0).

The normalized parameters of the constant vibration are: mean-square vibration acceleration values of the vibration velocity the vibration acceleration, which are measured in the octave (third octave) frequency

bands or their logarithmic levels; corrected by the frequency value of the vibration velocity and the vibration acceleration or their logarithmic levels. The normalized parameters of the inconstant vibration are the equivalent (by the energy) the corrected by the frequency value of the vibration velocity and the vibration acceleration or their logarithmic levels.

In case of the impact duration per working day less than 480 minutes the permissible value of the vibration velocity V_t is determined by the use of the following equation:

$$V_t = V_{480}\sqrt{\frac{480}{t}}, \text{ (28.2)}$$

where V_{480} — is the allowable vibration velocity in case of 480 min vibration impact duration;

t — is the period of the vibration impact per one working day, min.

The prevention of the vibration disease is achieved by the use of the vibration protection equipment and measures, working on the machines which have the vibration protection.

During the designing of the technological processes and the production buildings the machines and equipment with the low-vibration effect are to be chosen; the schemes of the machines' location all over the premise considering the minimum vibration levels on the working places; the assessment of the designed vibration load on the operator must be provided; the construction solutions of the building envelope and the structure of the floor slabs, basement etc. are made from the point of view of the vibration production safety requirements. (SN 30043-84, 15.07.84)

3. DANGEROUS AND HARMFUL EXPLOSION FACTORS

In accordance with GOST 12.1.010-76 the list of the dangerous and harmful factors which affect people in case of explosion is the following:

shock wave, the pressure on the front of which exceeds the allowable, flame and fire, equipment failure, communications failure, buildings and structures failure and the expansion of their fragments, and the emergency of the

dangerous substances which are contained in the output or damaged machines and tools occurred owning to the explosion and the total content of these substances in the air exceeds the MAC (the maximum acceptable content).

Shock wave is a space of instant compression of the surrounding environment, which extends all over the directions from the explosion. The pressure on the front of shock wave (ΔP_f) and the speed of its extension reduces in accordance with the remoteness from the core of explosion and as a result a shock wave becomes a simple acoustic wave. The way of changing the pressure in particular point in case of crossing it by the shock wave is introduced on the following chart. During the compression phase (t_+) the pressure reduces after crossing the leading front and then goes phase of discharge (t_-). In most cases the damaging and destructive actions of the shock wave are determined by the parameters of the compression phase, however, in case of containers with compressed gases or gas cylinders explosion and extended source of explosion phase discharge parameters achieve the highest values.
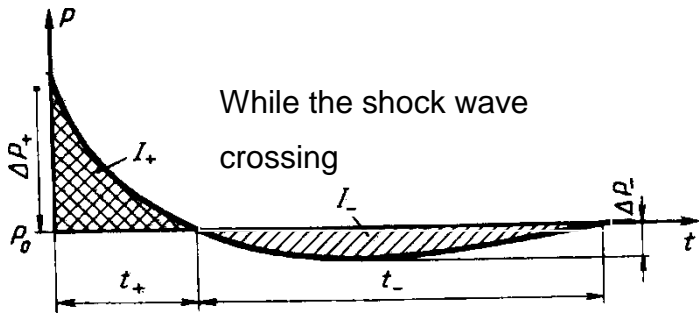
Figure 1.3. Pressure difference in particular plane while shock wave crossing.

The impulse of the compression phase which determines the effect of the shock wave on a human must be calculated using the following equation:

$$i = \int_0^{t_+} (P(t) - P_0)dt$$

, (1.3)

where P_0 is atmospheric pressure.

The reflected wave arises in case of interaction of the shock wave and the indestructible barrier. If the barrier is possessed perpendicular to the direction of

the wave propagation, the reflected surface pressure is determined using the following equation:

$$\Delta P_{\text{отр}} = 2\Delta P_f + 6\Delta P_f^2 / (\Delta P_f + 7P_o). \quad (2.3)$$

Fatal injuries or severe concussions happen when $\Delta P_f > 100$ kPa.

A human receives serious injuries in case of exceeded pressure which is equal to 60 – 100 kPa, when a pressure is 40 – 60 kPa, a human receives moderate injuries, in case of 20 – 40 kPa pressure, a human receives negligible injuries. In case of shock wave action the most vulnerable to its effect are those humans' organs which are filled gases or liquids, such as lungs or hearing organs. In spite of the direct harmful effect there are possible secondary and tertiary effects. Secondary effects include the injuries by the equipment splinter or the destructed construction elements. Tertiary effects imply the shock wave impact on the human's body and the subsequent braking stroke.

The lung damage depends on the ΔP_f, the time of wave action and the human's mass. The effect of the both last factors is characterized by the reduced impulse, which is determined using the following equation:

$$\bar{\iota} = i/P_0^{1/2} m_{\text{ч}}^{1/3}. \quad (3.3)$$

The probability of death in case of fragments injury depends on the fragments' mass and their speed of movement. The radius of the dangerous zone is expanded by the possibility of the fragment's action or the injuries by the destructed construction elements, because of the fact that injury is possible to be caused by the window glass collapse which occurs at a 2 – 7 kPa pressure.

3.1 DANGEROUS AND HARMFUL FIRE FACTORS

According to GOST 12.1.004-91 the list of the harmful fire factors is the following:

flame and sparks; the high environmental temperature; toxic products of the combustion and the thermal decomposition; smoke; reduced oxygen concentration. The secondary manifestations' harmful fire factors are: the fragments; parts of the destructed equipment and tools; radioactive and toxic substances and materials which are contained in the machines and equipment; the electrical current caused by receiving a high voltage by the electrical ducts of the building structure and the equipment; the harmful explosion factors caused by the fire extinguished agent.

The intensity of the fire impact on the human's skin is characterized by the heat flow dimension. In a compliance with the required evacuation time the dangerous density of the heat flow is $E > 0.3$ kW/m^2. The permissible time of the heat flow impact on the human can be measured using the following equation:

$$t = 0,013E^{-1,61}, \quad (4.3)$$

where t – is the time of impact, h.

Extremely high environmental temperature entails the burns of the respiratory and skin. On relation to the physically healthy people 10 minutes impact of the 80 - 100 °C temperature is acceptable.

The 60 °C temperature is acceptable for evacuation time calculating. The skin heating which is exceeded 45°C causes harmful feelings. The time of the heating till 45°C can be estimated using the following equation:

$$t = (35 / E)^{1,33}, \quad (5.3)$$

where t – is the heating time, s.

The skin heating till 77 °C causes its immediate pain, at 149°C temperature almost immediate inhalation burn occurs.

Statistical research shows that in fire situation more than 70% of people die because of the combustion products' poisoning. The most prevalent toxic products are CO_2 and CO. The maximum permissible CO_2 content is 6%. A

10 – 12% concentration entails death. The maximum permissible CO concentration is 0.1%.

Low oxygen content may lead to the people death despite of the toxic gases absence. As a maximum permissible level of oxygen content 17% is accepted in case of the evacuation.

The toxic characteristics of the extinguishing agents are given in their technical specification.

3.2 PROBABILITY ASSESSMENT OF THE EXPLOSIVE DANGEROUS SITUATIONS' OCCURRENCE

In accordance with GOST 12.1.010-79 the probability of the explosion on any object must not exceed 10^{-6} during one year or the possibility of the dangerous fire factors' impact on the people must not exceed this value. In accordance with GOST 12.1.004-91 the prevention level of the dangerous factors impact on the people must be more than 0.999999. The maximum permissible impact level of the dangerous factors which exceed the maximum acceptable values must be less than 10^{-6} for each person in one year.

The possibility of the dangerous factors' impact on the human is determined using the following equation:

$$Q_{в} = Q_P (1 - P_{э}) (1 - P_{п.з}) , \quad (6.3)$$

where $Q_в$ – is the possibility of the dangerous factors impact on human;

Q_P – is the possibility of the fire occurrence;

P_e – is the possibility of human's evacuation;

P_{pz} – is the possibility of the technical design effectiveness of the fire protection system.

P_e must be calculated in accordance with the designed people's evacuation time and the time till the locking of all evacuation ways because of the excessive values of dangerous factors.

$$P_{n.3} = 1 - \prod (1 - R_i) \quad , (7.3)$$

where n – is a technical solutions quantity of the fire protection system inside the building.

R_i – is the possibility of the technical premises effective work .

For the exploited buildings the possibility of the dangerous factors' impact on the people must be checked using the following equation:

$$Q_v = mM_g / (TN_0) \quad , (8.3)$$

where m – is the coefficient taken in accordance with the possible number of injured people;

T – is the period of exploitation of the same type building, year;

M_g – is a number of injured people owning to the fire in the group of buildings during the period T;

N_0 – is the total quantity of the people which was in the building.

The method of the possibility of fire or explosion occurrence calculation inside the fire and explosion dangerous object is introduced in GOST 12.1.004-91. The probability of the explosion occurrence in all premises of the building must be taken into account in case of its initiation either in one particular premise.

Table 1.3. Necessary number of the fire extinguishers depending on the premises' floor area and its category

Premises' category		A, B, V (flammable liquids or gases)					V			G		G, D			Public buildings	
Maximum protected area		200					200			800		1800			800	
Fire class		A	B	C	D	(E)	A	C	(E)	D	C	A	D	(E)	A	(E)
Foam or water fire extinguishers 10l capacity		2 ++	4 +	-	-	-	2 ++			2 +		2 ++			4 ++	
Powder fire extinguishers l/mass of extinguishing agent capacity, kg	2/2	2 ++	-	-	-	-	4 +	-	-	-	4 +	4 +	-	4 +	8 +	-
	5/4	2 +	2 +	2 +	2 +	2 +	2 ++	2 +	2 ++	2 ++	2 ++	2 ++	2 +	2 ++	4 ++	4 ++
	10/9	1 ++	1 ++	1 ++	1 ++	1 ++	1 +	1 ++	1 +	1 +	1 +	1 +	1 ++	1 +	2 +	2 ++
Chladone extinguishers 2-3l capacity		-	4 +	4 +	-	-	-	-	2 +	-	-	-	-	2 +	-	4 +
Carbon dioxide fire extinguishers l/mass of extinguishing agent capacity, kg	2/2	-	-	-	-	-	-	-	4 +	-	-	-	-	4 +	-	4 +
	5(8)/3(5)	-	-	-	-	2 ++	2 +	-	2 ++	-	-	-	-	2 ++	4 +	2 ++

64

3.3 EMERGENCY PLAN DEVELOPMENT
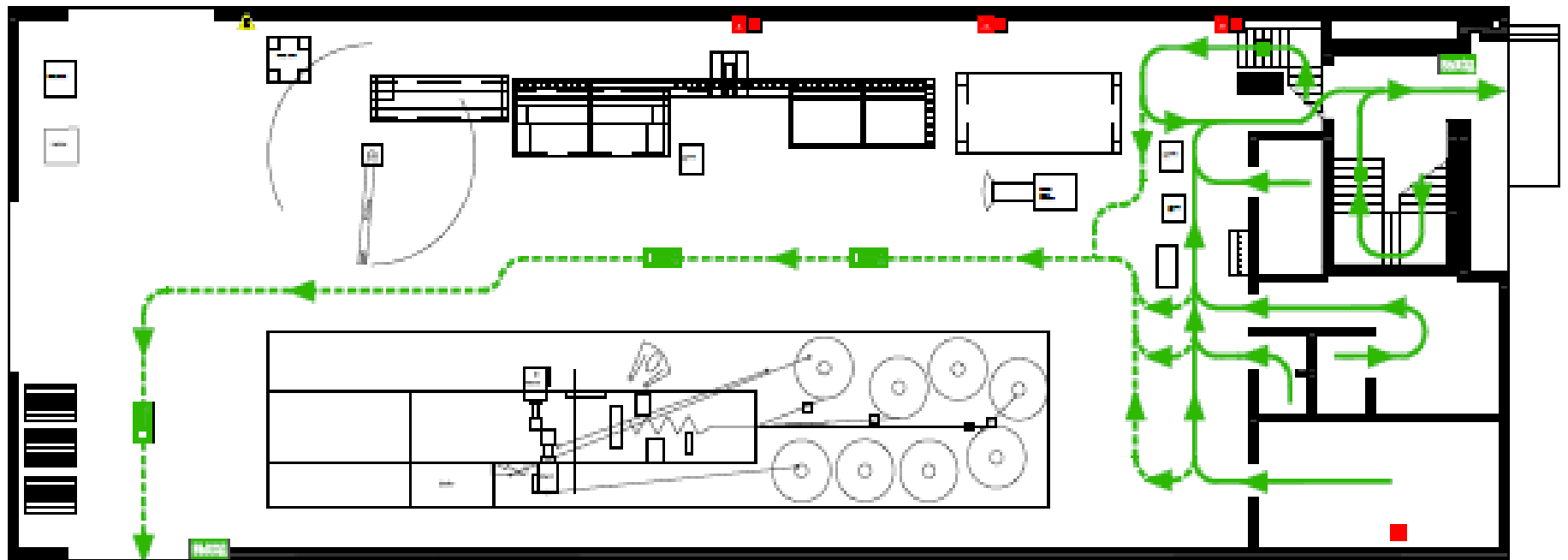
Figure 2.3. Emergency plan.

In accordance with the SNiP 21-01-97* the exits are called emergency if they:

- are directed from the premises of the first floor to outside:

- direct;

- through the corridor;

- through the hall;

- through the stairwell;

- through the corridor and hall;

- through the corridor and stairwell;

- are directed from the premises of any other floor apart of the first floor :

- directly on the stairwell or on the 3[rd] type stair;

- to the hall which is straightly directed to the stairwell or on the 3[rd] type stair;

- to the corridor which is straightly directed to the stairwell or on the 3[rd] type stair;

Exits are not emergency if sliding or lifting trapdoors and gates are installed in their openings.

The premise of this type of production can be characterized as F5.1 class. This fact means that only one emergency exit is enough, but if there are two emergency exits they must be possessed with the minimum distance L,m between them:

in case of exit from the premise: $L \geq 1.5\sqrt{P}/(n-1)$; $L \geq 1.5\sqrt{16.16}/(2-1)$; $L \geq 6$ m

in case of exit from the corridor: $L \geq 0.33D/(n-1)$; $L \geq 0.33 \cdot 31/(2-1)$; $L \geq 10.2$ m

where: P – is the perimeter of the premise, m;

n – is a number of the emergency exits;

D – is the total distance of the corridor, m.

The height of the emergency exit must be at least 1.9 m, the width not less than 0.8 m.

The width of the outside doors of the stairwells and the doors from the stairwells to the hall must not be less than the design value of the width or not less than the width of the stairs flight.

The doors of the emergency exits must open in accordance with the direction of escape of the building.

The doors of emergency exits from the corridors, halls and stairwells must not have any block system which may prevent its free opening from the inside without the key. In the buildings with the total height exceeding 15 m such kind of doors must be blind or with the reinforced glass.

In the emergency the appropriate lighting must be provided in accordance with SNIP 23-05.

The length of an emergency way from the work place must be determined in accordance with the functional fire danger class and premise and building exposure danger category, the total amount of the people staying inside the building, the premise and the emergency ways geometrical parameters, structural fire danger class and the level of fire resistance.

The length of the emergency way across the stair of the 2nd class is equal to its height.

Table 2.3. Classification of the stairs and the stairwells.

Stairs		Stairwells	
Emergency stairs	Fire stairs	In accordance with the level of the smoke resistance during the fire	
Internal stairs which are placed on the stairwells	P1: Vertical stairs	Normal stairwells	Smoke resistant stairwells
Internal open stairs	P2: Floating stairs with the slope less than 1:6	L1: stairwells with the daylight through the glassed or free openings in the outside walls on the each floor	N1: stairwells with the entrance on the stairwell from the floor through the unsmoked external air zone across the open passage
External open stairs		L2: stairwells with the daylight through the glassed or free openings in the coating	N2: stairwells with the overpressure during the fire
			N3: stairwells with the entrance from the each floor through the locks in which overpressure is provided during the fire

All emergency ways must not include any lifts and escalators; moreover they must not contain directions lying:

- through the corridors with the exits from the lift shafts, lift halls and tambours in front of the lifts, if the lift doors do not meet the requirements, which are proffered to the fire protection barriers;
- through the stairwells when it is a part of the corridor, and besides through the premise, which contains the 2nd type stair which does not serve as the fire stair;

- on building roofing in spite of the exploitive roofing or a specially equipped part of the whole roofing;
- on the 2nd type stairs, which connect each together more than two floors and which are directed from the basements and underground floors.

Across the emergency ways in the buildings of all levels of fire resistance and structural fire danger classes, in spite of the 5th level of fire resistance and C3 class buildings, it is forbidden to apply any materials the fire danger level of which is higher than the following values:

- G1, V1, D2, T2 – for the wall, ceiling finishing and the hanging ceiling filling in the halls, stairwells and the lift halls;
- G2, V2, D3, T3 or G2, V3, D2, T2 – for the wall, ceiling finishing and the hanging ceiling filling in the common corridors and halls;
- G2, RP2, D2, T2 – for the floor finishing in the halls, stairwells, lift halls;
- G2, RP2, D3, T2 – for the floor finishing in the common halls, stairwells.

In the premise F5 class A,B and V1, in which the flammable liquids are produced, applied or saved, the floors are to be made without flammable materials or G1 materials.

If the length of the corridor is more than 60 m, it must be divided by the fire resistant barrier of the 2nd type on several parts, the length of each of this part must be determined in accordance with SNiP 2.04.05, but must not exceed 60m.

In case of the doors open from the premises to the corridors the width of the emergency way must be reduced by:

- the half of the width of the door opening – in case of one direction possessed doors;
- the width of the door opening - in case of two direction possessed doors.

The height of the horizontal parts of the emergency way must not be less than 2 m, the width of the horizontal parts of the emergency ways must not be less than:

- 1.2 m – for the common corridors, from which 50 people can be evacuated;
- 0.7 m – for the way to the work place;
- 1.0 m – in all other cases.

In all cases the width of the emergency exit must be appropriate for the transportation of the stretcher with a lying man on them.

In the floor structure of the emergency way it is not allowed to have the height difference more than 45 sm and the ledge in spite of the doorsteps. In places with the height differences the stairs with at least three steps or the rampant with the slope not more than 1:6 must be organized.

In case of the stair height more than 45 sm railings must be provided.

The width of the stair which must be appropriate for people evacuation must not be less than the design value or not less than the width of any other evacuation exit on it, but as a rule not less than 0.7m – for the stairs directed to the particular workplace and 0.9 m in all other cases.

The slope of the emergency stairs must not be more than 1:1, the width of the step not less than 25 sm, the height of the step not more than 22 sm.

The slope of the open stairs which lead to the particular work places can be increased till 2:1.

The stairs of the 3[rd] type are to be made of inflammable materials and are to be possessed near with the blind wall parts of not less than K1 class and their maximum fire resistance must not be less than REI 30.

3.4 CALCULATION OF THE ACTUAL EVACUATION TIME
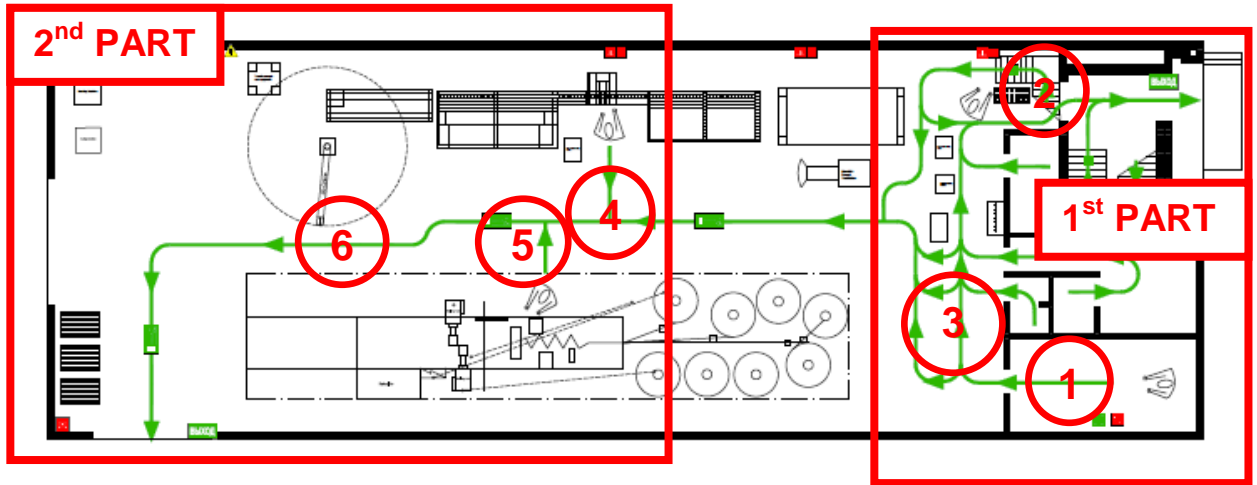
Figure 3.3. Emergency plan areas.

In the red circles the numbers of the emergency plan areas are stated.

The first area is going from the Production Manager cabinet.
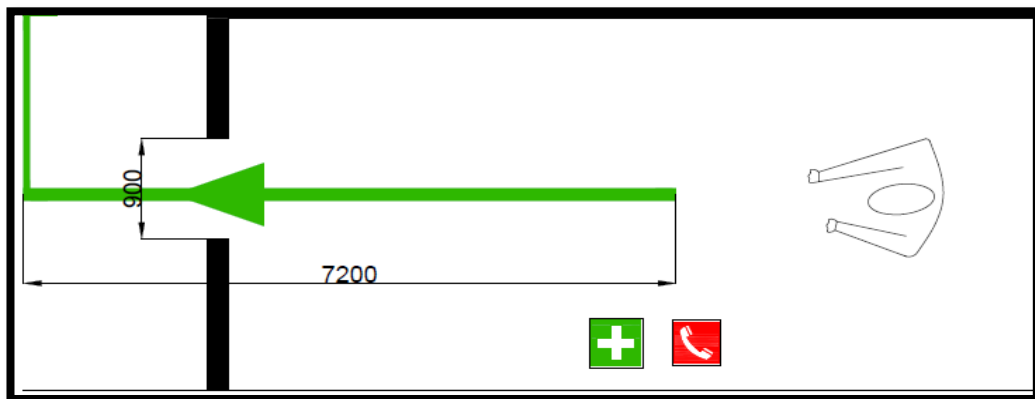
Figure 4.3. First emergency area.

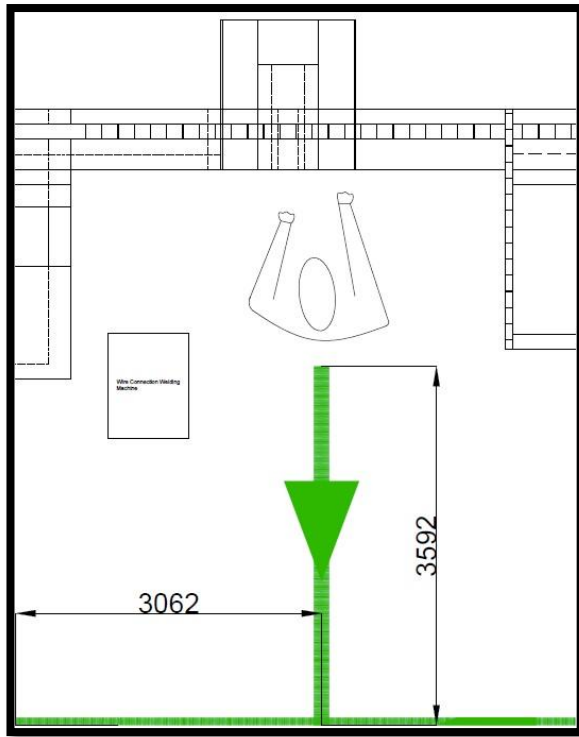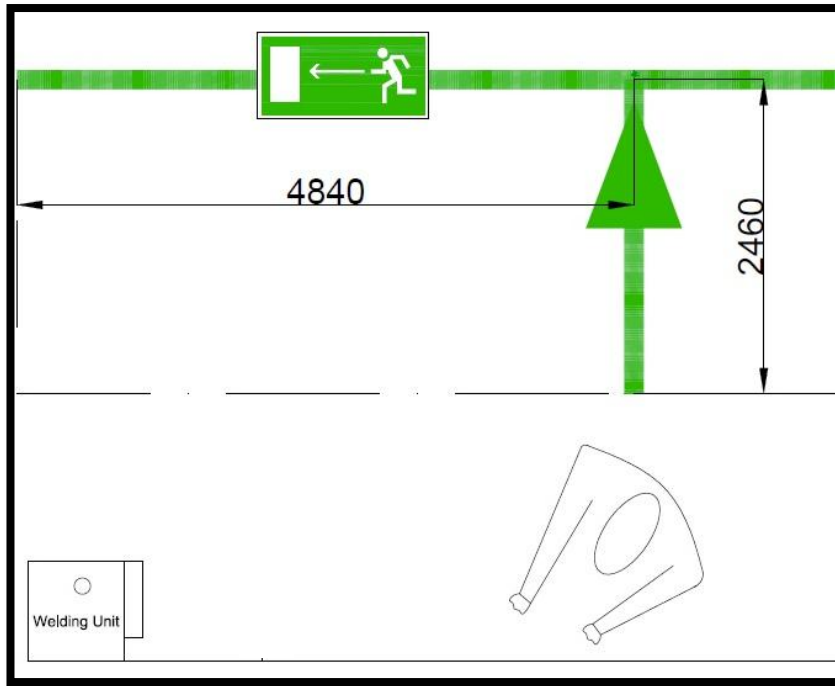$N_1 = 1$ - is the number of people on the emergency area;

$f = 0.1$ - is the average man projection, m^2;

$l_1 = 7,2$ - is the length of the emergency area, m;

$b_1 = 0.9$ - is the width of the emergency area, m;

$D1 = \frac{N_1 \cdot f}{l_1 \cdot b_1} = \frac{1 \cdot 0.1}{0.9 \cdot 7.2} = 0.015$ - is the people flow density; (9.3)

$v_1 = 100$ - is the average speed of the people flow, is taken from the reference table in dependence on the people flow density, m/min;

$$t1 = \frac{l_1}{v_1} = \frac{7.2}{100} = 0.072 \text{min}; \quad (10.3)$$

The second area goes from the welding zone.
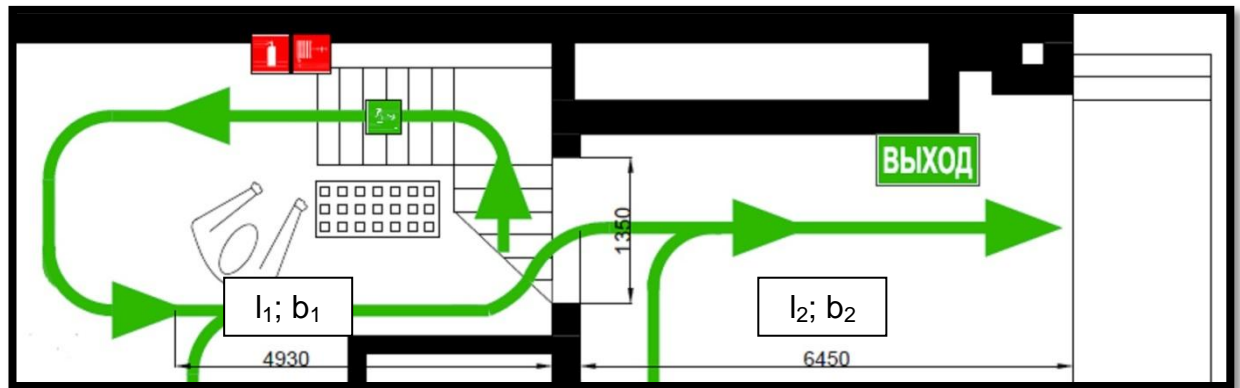
Figure 5.3. Second emergency area.

$q_1 = 1$ - is the intensity of the people flow movement, m/min;

$$q_i = \frac{q_{i-1} \cdot b_{i-1}}{b_i} = \frac{1 \cdot 0.9}{1.35} = 0.74 \text{ m/min};$$

$N_2 = 2$ - is the number of people on the emergency area;

$f = 0.1$ - is the average man projection, m^2;

$l_2 = 4.93 + 6.45$ - is the length of the emergency area, m;

$b_2 = 0.9 \div 1.35$ - is the width of the emergency area, m;

$$D_{2,1} = \frac{N_1 \cdot f}{l_1 \cdot b_1} = \frac{2 \cdot 0.1}{4.93 \cdot 0.9} = 0.045; \quad D_{2,2} = \frac{N_1 \cdot f}{l_1 \cdot b_1} = \frac{2 \cdot 0.1}{6.45 \cdot 1.35} = 0.023 \quad \text{- is the people flow}$$
density;

$v_2 = 100$ - is the average speed of the people flow, m/min;

$$t_2 = \frac{l_1 + l_2}{v_1} = \frac{4.93 + 6.45}{100} = 0.114 \text{ min};$$
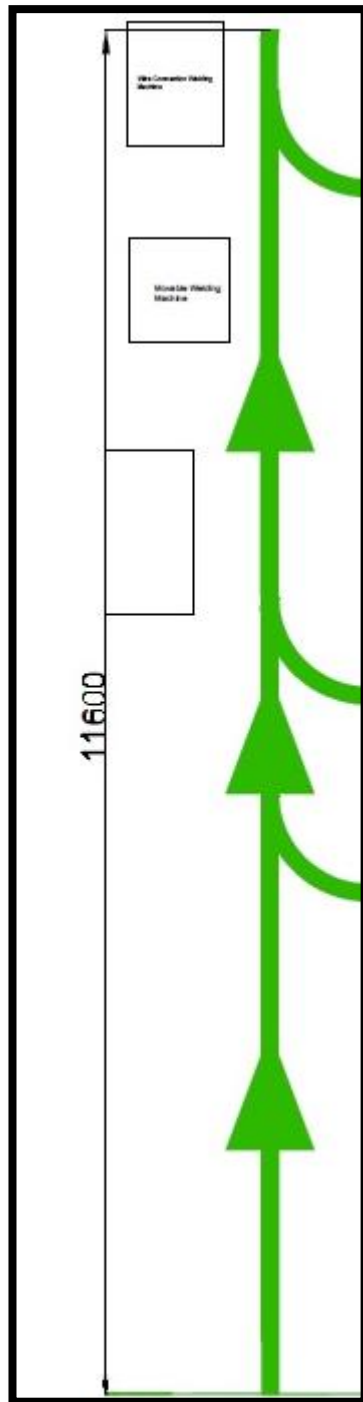
The third area goes from the first welding area to the second area.

$N_3 = 1$ - is the number of people on the emergency area;

$f = 0.1$ - is the average man projection, m^2;

$l_3 = 11.6$ - is the length of the emergency area, m;

$b_3 = 0.9$ - is the width of the emergency area, m;

$D_3 = \frac{N_3 \cdot f}{l_3 \cdot b_3} = \frac{1 \cdot 0.1}{0.9 \cdot 11.6} = 0.001$ - is the people flow density;

$v_3 = 100$ - is the average speed of the people flow, taken from the reference table in dependence on the people flow density, m/min;

$t_3 = \frac{l_1}{v_1} = \frac{11.6}{100} = 0.116$ min;

Figure 6.3. Third emergency area.

The total time of the first part of the evacuation plan:

$t_1 + t_2 + t_3 = 0.072 + 0.114 + 0.116 = 0.302$ min $= 18.12$ sec

73

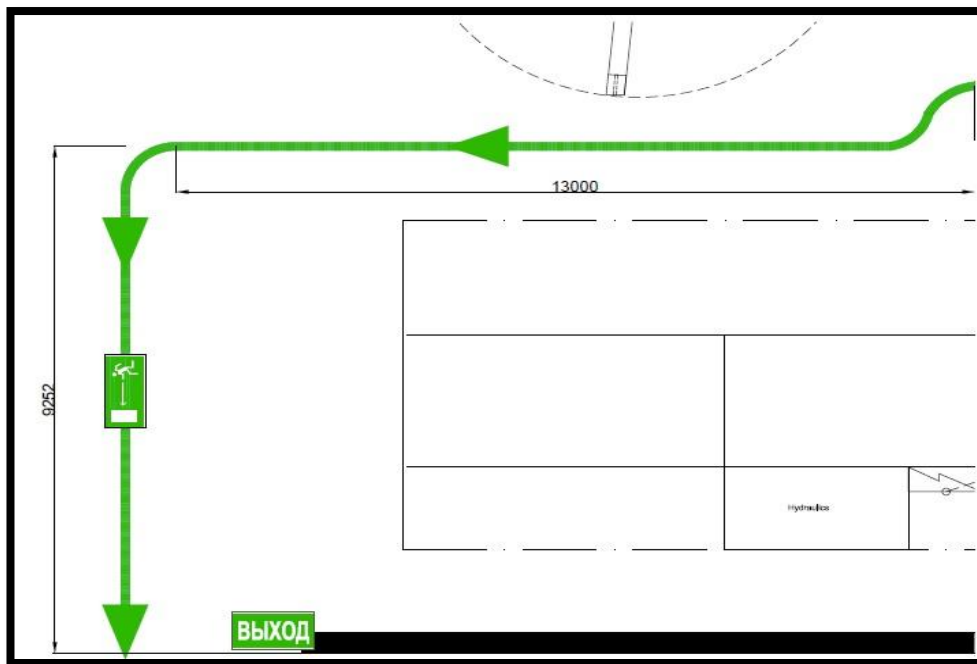The fourth area goes from the Terra Joint zone.

Figure 7.3. Fourth emergency area.

N_4 =1 - is the number of people on the emergency area;

f = 0.1 - is the average man projection, m^2;

l_4 = 3.592+3.062 - is the length of the emergency area, m;

b_4 = 0.9 - is the width of the emergency area, m;

$D_{4,1} = \frac{N_4 \cdot f}{l_{4,1} \cdot b_4} = \frac{1 \cdot 0.1}{0.9 \cdot 3.592} = 0.031$; $D_{4,2} = \frac{N_4 \cdot f}{l_{4,2} \cdot b_4} = \frac{1 \cdot 0.1}{0.9 \cdot 3.062} = 0.036$ - is the people flow density;

v_4 = 100 - is the average speed of the people flow, is taken from the reference table in dependence on the people flow density, m/min;

$t_4 = \frac{l_{4,1} + l_{4,2}}{v_4} = \frac{3.592 + 3.062}{100} = 0.067$ min;

The fifth area goes from the PD zone.

Figure 8.3. Fifth emergency area.

$N_{5,1} = 1$; $N_{5,2} = 2$ - is the number of people on the emergency area;

$f = 0.1$ - is the average man projection, m^2;

$l_5 = 2.46 + 4.84$ - is the length of the emergency area, m;

$b_5 = 0.9$ - is the width of the emergency area, m;

$D_{5,1} = \frac{N_{5,1} \cdot f}{l_{5,1} \cdot b_5} = \frac{1 \cdot 0.1}{0.9 \cdot 2.46} = 0.045$; $D_{5,2} = \frac{N_{5,2} \cdot f}{l_{5,2} \cdot b_5} = \frac{2 \cdot 0.1}{0.9 \cdot 4.84} = 0.046$ - is the people flow density;

$v_5 = 100$ - is the average speed of the people flow, is taken from the reference table in dependence on the people flow density, m/min;

$t_5 = \frac{l_{5,1} + l_{5,2}}{v_5} = \frac{2.46 + 4.84}{100} = 0.073$ min;

The sixth area goes from the fourth and fifth areas.

Figure 9.3. First emergency area.

N_6 =2 - is the number of people on the emergency area;

f = 0.1 - is the average man projection, m^2;

l_6 = 13 + 9.252 - is the length of the emergency area, m;

b_6 = 0.9 - is the width of the emergency area, m;

$D_6 = \frac{N_6 \cdot f}{l_6 \cdot b_6} = \frac{2 \cdot 0.1}{0.9 \cdot (13+9.252)} = 0.01$ - is the people flow density;

v_6 = 100 - is the average speed of the people flow, is taken from the reference table in dependence on the people flow density, m/min;

$t_6 = \frac{l_6}{v_6} = \frac{23.252}{100} = 0.232$ min;

The total time of the first part of the evacuation plan:

$t_4 + t_5 + t_6 = 0.067 + 0.073 + 0.232 = 0.373$ min = 22.35 sec

3.5 FIRE RISK CALCULATION
ANALYSIS OF THE PROTECTION OBJECT FIRE DANGER

The object is a separate three storey building without the basement. The functional fire danger class of this building is F5.1.

The building of the object corresponds the II level of fire resistance and C0 structural fire danger class.

The plan of the building is rectangular with the dimensions 72 x 84 m.

The total square of the building is 6 138.96 m^2.

The building volume is equal to 82875.96 m^3.

The content of the building includes the welding production factory which has the 5.1F class of the functional fire danger; the office premises, which have 4.3F class of the functional fire danger; the storage premises which have 5.2F.

The building consists of the five fire prevention compartments which are separated from each other by the fire resistant wall of the II type with the maximum fire resistant REI 45.

In the building premises the general exchange supply ventilation system is provided. Ventilation works with the natural and mechanical stirring.

Heat supply is provided from the municipal heating networks.

The premises' heating system is the central water.

Heat transmittance is provided by the water with the high temperature which is equal to 90-70 °C.

In the structure of the building the internal fire water system is applied.

The building electricity is provided in accordance with the technical conditions of the power supply reliability of the II category.

The protection from the direct lighting strikes, from its secondary consequent factors of action and from the static electricity is provided in accordance with SO-153-34.21.122-2003 "Instruction for the lighting protection system installation on the buildings, facilities and industrial communications".

In view of the type of the flammable load (solid combustible substances and materials, gas cylinders) the temperature regime of the possible fire will be approximately the same as the standardized value for such type of the building purpose. As a result the building structures will serve during the time corresponding the fire resistance.

The fire spread through the building structures is provided by the fire danger of the basic design elements. Considering these facts it can be assumed that the possibility of the fire spread through the main structural elements of the building is quite low.

In case of the fire ignition in the building premises the rapid distribution of the combustion products through the total volume of the fire areas, adjacent areas, evacuation routes is possible. This fact may pose a threat to the people health and life.

3.6 ESTIMATION OF THE FIRE DANGEROUS SITUATIONS' FREQUENCY

The frequency of the fire dangerous situations' implementation is determined by the frequency of the fire occurrence in the building during the whole year (Q_p):

For the industrial premises (scenario 1):

$Q_p = 4 \times 10^{-2}$. (11.3)

For the storage premises (scenario 2):

$Q_p = 4 \times 10^{-2}$. (12.3)

For the administrative premises or offices (scenario 3)

Q_p=4 x 10^{-2}. (13.3)

The placement of the flammable materials and objects (flammable load) in the premises is provided in dependence with the functional role of the premises and the special features of the saving objects.

3.7 CREATION OF THE DANGEROUS FIRE FACTORS FIELDS CHOICE OF THE SCENARIOS OF THE FIRE DISTRIBUTION

The placement of the flammable materials and objects (flammable load) in the premises is provided in dependence with the functional role of the premises and the special features of the saving objects.

The worst scenario of the fire distribution can be characterized by several main features:

- the worst conditions of the people evacuation;

- the highest dynamics of the fire dangerous factors' growth.

The case of ignition in the welding production factory the premise number 1.3 on the first floor is considered.

The flammable load in case of ignition in the factory premise includes several gas cylinders with the oxygen and acetylene; wooden packing materials.

The average value of the flammable load, q, mkal/m^2, is equal to 100 mkal/m^2.

The following facts must be considered for the estimation of the evacuation ways' locking time:

- the fire premise doors stay open and as a result the combustion products enter the adjacent premises;

- the calculations are made with the use of average flammable load which is introduced in the reference data;

- the geometrical position of the flammable load in the premises does not affect the mass and heating exchange with the environment through the open apertures and thermal transmittance to the building structures;

79

- the discrete of the calculations on time is accepted 5 s.

Initial values:

- Initial pressure at zero – 101325 Pa;

- Initial lighting – 50 Lk;

- Initial oxygen concentration - 21% of the total volume;

- Initial nitrogen content - 0,878 kg/kg;

- Initial oxygen content - 0,267 kg/kg;

- Specific isobaric heat capacity - 100,24 J/kg*K;

- Molar mass of the air - 28,84 g/mol.

Table 3.3. Characteristics of the flammable load.

1. Textile	
Factor	Value
Lower heat of the combustion, kJ/kg	16700
Linear fire velocity, m/s	0,0071
Specific rate of burnout, kg/m^2*s	0,0244
Smoke-forming ability, H*m^2/kg	60,6
Oxygen consumption, kg/kg	2,5600
Gases emission	
CO_2, kg/kg	0,8790
CO, kg/kg	0,06260
HC_1, kg/kg	0,0000
2. Packing: paper, cardboard, wrapper	
Lower heat of the combustion, kJ/kg	23540
Linear fire velocity, m/s	0,004
Specific rate of burnout, kg/m^2*s	0,0132
Smoke-forming ability, H*m^2/kg	172
Oxygen consumption, kg/kg	1,7
Gases emission	
CO_2, kg/kg	0,697
CO, kg/kg	0,112
HC_1, kg/kg	0,0037
3. Wooden wrapper	
Lower heat of the combustion, kJ/kg	20710
Linear fire velocity, m/s	0,01
Specific rate of burnout, kg/m^2*s	0,018
Smoke-forming ability, H*m^2/kg	155
Oxygen consumption, kg/kg	1,52
Gases emission	

CO_2, kg/kg	0,97
CO, kg/kg	0,094
HC_1, kg/kg	0,0046
4. Furniture and paper	
Lower heat of the combustion, kJ/kg	14000
Linear fire velocity, m/s	0,042
Specific rate of burnout, kg/m^2*s	0,0129
Smoke-forming ability, $H*m^2/kg$	53
Oxygen consumption, kg/kg	1,161
Gases emission	
CO_2, kg/kg	0,642
CO, kg/kg	0,0317
HC_1, kg/kg	0,0000
5. Gases cylinders	
Lower heat of the combustion, kJ/kg	56190
Linear fire velocity, m/s	6,2
Gas emission	
CO_2, kg/kg	6

Table 4.3. Ultimate limit dangerous fire factors values.

	Factors	Values
1	Temperature value, ^0C	70
2	Partial oxygen value	0,226
3	CO_2 content, $kg*m^3$	0,11
4	CO content, $kg*m^3$	$1,16 \times 10^{-3}$
5	HCL content, $kg*m^3$	23×10^{-3}

The ultimate limit values in terms of the "sight loss" are taken equal to the maximum horizontal linear dimension of the considering premise. The smoke optical density in normal terms depends on the limited visibility distance:

l_{lim} = 2.38 / h, where the h - is the smoke optical density indicator;

h = 2.38 / l_{lim}

For the cabinet l_{lim1} = 8.888 m.

For the main factory premise l_{lim2} = 44.014 m.

h_1 = 2.38 / 8.888= 0.268, m^{-1}

h_2 = 2.38 / 44.041= 0.054, m^{-1}

3.8 RESULTS OF FIRE MODELING USING THE PROGRAM CFAST (THE CONSOLIDATED MODEL OF FIRE AND SMOKE TRANSPORT)

For the illustration of the heat, hot gas release and the transmittance possible situation the following charts are introduced. They describe the changes in the premise microclimate in terms of the fire occurrence in the main factory premise.
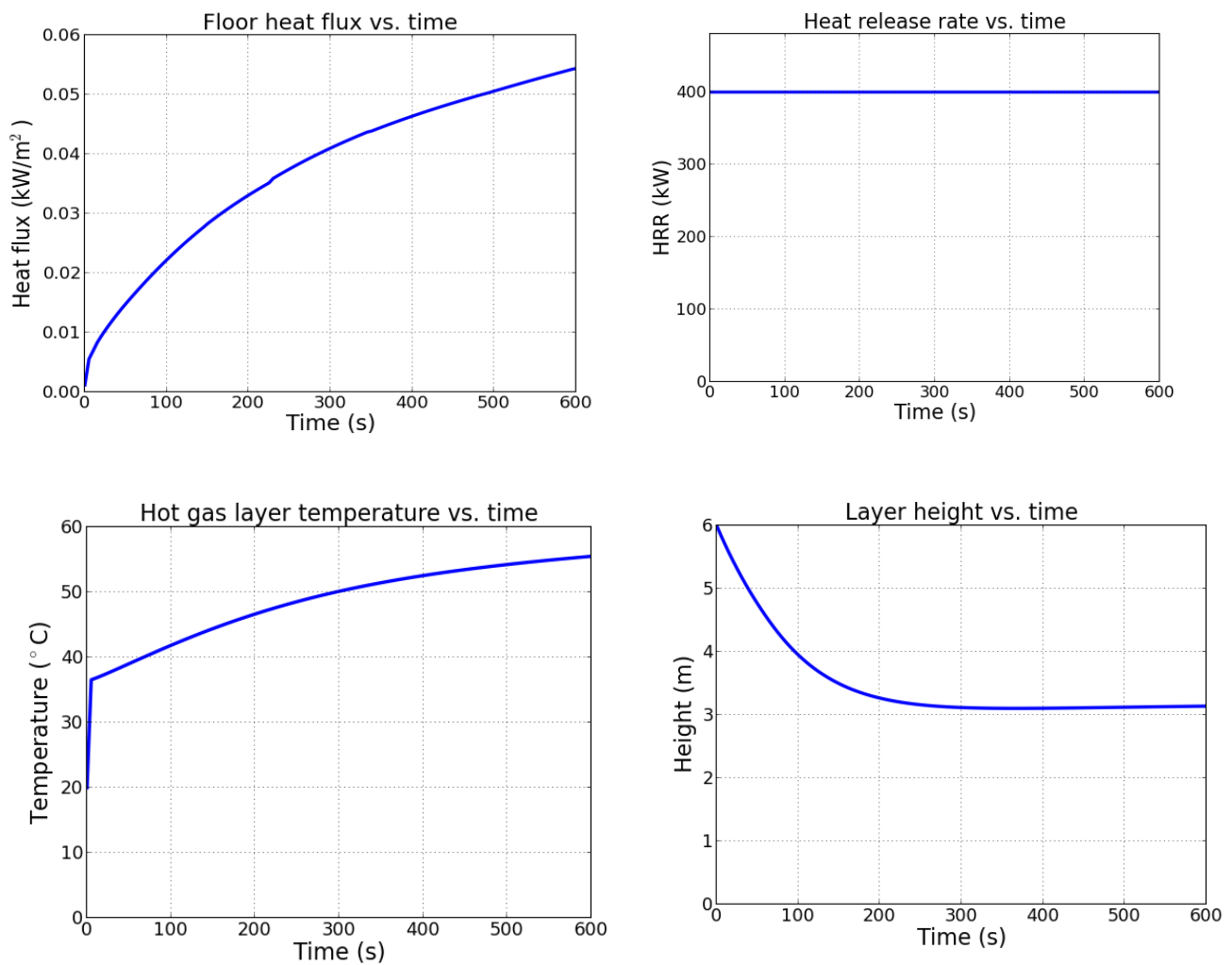
Figure 10.3. Fire modeling results.

3.9 CALCULATION OF THE FIRE DANGER RISK VALUE

The design value of the fire risk in the building:

$$Q_v = \max\{Q_{v1}, \ldots, Q_{vi}, \ldots, Q_{vN}\}, \quad (14.3)$$

where

$Q_{v,I}$ – is a design value of the fire risk for the fire scenario number I;

N – a number of considered scenarios

The design value of the fire risk, $Q_{v,I}$, for the scenario number i:

$Q_{v,I} = Q_{p,i} \cdot (1 - K_{ap,i}) \cdot P_{pr,i} \cdot (1 - P_{e,i}) \cdot (1 - K_{pz.i})$, (15.3)

where

$Q_{p,i}$ – is a frequency of the fire occurrence inside the building during one year;

$K_{ap,i}$ - is a coefficient which corresponds to the level of readiness and performance of the fire equipment; in this case this coefficient is equal to 0;

$P_{pr,I}$ – the possibility of the people presence inside the building;

$P_{pr,I} = t_{funct}/24$, (16.3)

where

t_{funct} – is a time of people presence inside the building and is equal to 16 hours.

$P_{pr,I} = t_{funct}/24 = 16/24 = 0.67$, (17.3)

$P_{e,I}$ – is the possibility of people evacuation;

$K_{pz.i}$ – is the coefficient which depends of the level of the fire prevention system work and performance with the purpose to find out its correspondence to the standardized model of such system in case of people evacuation.

$K_{pz.i} = 1 - (1 - K_{obn} \cdot K_{soue}) \cdot (1 - K_{obn} \cdot K_{pdz})$, (18.3)

where

K_{obn} – is the coefficient which takes in to account the correspondence of the fire alarm system to the standardized requirements of the fire safety. In this case is equal to 0.

K_{soue} – is the coefficient which takes in to account the correspondence of the warning people system to the standardized requirements of the fire safety. In this case is equal to 0.

K_{pdz} – is the coefficient which takes in to account the correspondence of the smoke prevention system to the standardized requirements of the fire safety. In this case is equal to 0.

$K_{pz.i} = 1 - (1 - K_{obn} \cdot K_{soue}) \cdot (1 - K_{obn} \cdot K_{pdz}) = 0$

$Q_{v,I} = Q_{p,i} \cdot (1 - K_{ap,i}) \cdot P_{pr,i} \cdot (1 - P_{e,i}) \cdot (1 - K_{pz.i}) = 0.04 \cdot (1 - 0) \cdot 0.67 \cdot (1 - 0.999) \cdot (1 - 0) = 2.68 \cdot 10^{-5}$

Conclusion:

The result is unsatisfactory. The fire alarm system must be developed.

4. OCCUPATIONAL SAFETY

All types of the works on the factory are to be performed in accordance with the relevant standardized guidelines.

The employer should organize the relevant trainings for the workers during one month after their hiring. Those trainings must provide the necessary information about the type of the works which will be performed by the employees, the safe method of that performance, hazards which may threaten the workers. Further during the working process the periodical trainings and the examination of the occupational safety rules are to be organized by the employer for the worker at least one time in three years.

For the workers of the Peikko's factory several standard instructions are to be developed in accordance with the type of their job.

HIRING

↓

MEDICAL CERTIFICATION

↓

INITIAL TRAINING

↓

INITIAL TRAINIG ON THE WORKPLACE

↓

TRAININGS/EXAMINTIONS
(1 time on 3 years)
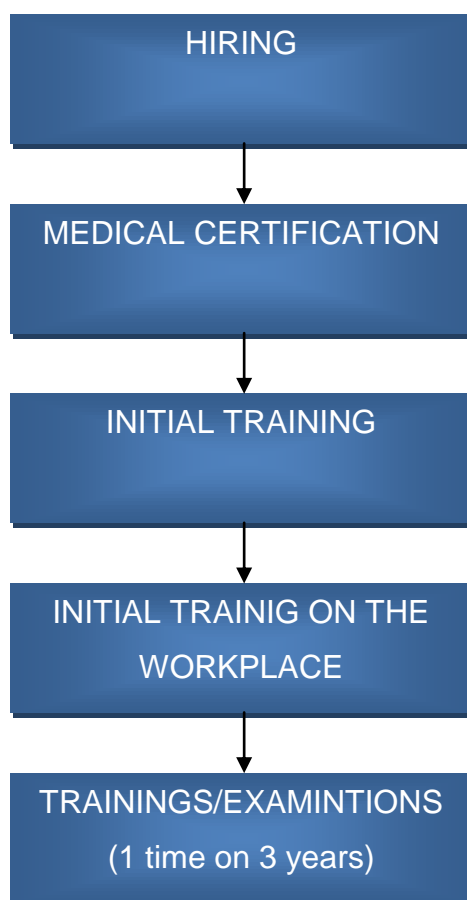
Figure 1.4. Preparation for the work new employees.

4.1 GENERAL REQUIREMENTS

Persons who are allowed to independent operation of the auto-loader are not to be less than 18 years old, they are aware of the theoretical and practical aspects of their work, they have already passed the examination and have the certificate on the relevant right of the auto-loader operation.

Before the admission to work auto-loader drivers have to pass physical examination, induction on safety of work, initial instructing on a workplace and obtain the practical knowledge about the safety auto-loader's operation way.

The results of the examination and skills, which were obtained at instructing, are to be made out by the entry in the initial training's log. In case of some contraindications of the former work's performance in view of the health's state according to the medical certificate the auto-loader's driver is transferred to another workplace.

During the work process possible dangerous and harmful production factors may threaten the worker:

- moving cars and mechanisms;

- moved and stored freights;

- high dust concentration in the working air;

- lowered air temperature of the working zone;

- insufficient illumination of the working zone;

- sharp edges of the equipment's surface and tool.

Auto-loader's drivers are to be provided with the individual protection items according to the working conditions:

- cotton overalls;

- rubber boots;

- combined mittens.

At external works in winter time:

- cotton jacket and trousers on the warming laying.

During the loading and unloading works and transporting freights it is necessary to adhere to the accepted technology of the cargo handling. It is not allowed to apply the accelerating performance's ways which lead to the violation of safety requirements. It is prohibited to operate faulty loaders. Responsible person for the maintenance of load-lifting cars is the driver or the production manager.

The auto-loader must always be clean. In the cabin there should not be any foreign subjects. Tools and all necessary details have to be put away in special places. In winter time it is necessary to look after that the territory of the work's performance is cleaned of ice and snow.

In dark time with the lack of the sufficient artificial illumination of storage zone drives the driver has to stop the work and inform the responsible for the safe works on this zone person. Drivers have to control the frequency of auto-loader's maintenance and if it is needed inform the responsible person about it. During the work time it is necessary to observe the correct meal schedule, work and rest schedule. It is necessary to have a rest and smoke only in specially taken away places.

When driving through the territory of the enterprise it is necessary to use only the established drives. Speed of movement on the territory should not exceed 10 km/h and in the premise area 5 km/h. Before the work's start drivers have to check the serviceability of the personal protection items; to investigate the roads, drives on which the freight's transportation will operate; to check the serviceability of a freight elevator; to be convinced of chains' damages' absence and serviceability of their fastening to a frame and the freight elevator carriage, to check by

external survey welded seams of top arms, chains, reliability of fingers' fastening, hinges of levers and also the operation of all auto-loader's mechanisms; to check the tires' condition and pressure inside them; to investigate the engine; to check whether it is the fuel's leak from a tank, pump and cranes, to check the brake fluid's in the main cylinder and also whether flexible hoses are damaged; to check action of foot and manual brakes, to make their adjustment if it is needed; to check the serviceability of steering's amplifier, connection of steering levers and drafts and also spherical fingers of the amplifier; to be convinced of correct action of a sound signal, a stoplight and lamps of turns, switches of light of headlights, a back lamp; to check operation of lifting and inclination of a frame of a freight elevator.

The norm of the loads transport on a flat and horizontal surface per one person should not exceed 50 kg, freight with a mass exceeding 50 kg must be transferred by at least two workers. It is necessary to transfer lengthy materials (logs, pips, etc.) by special captures and adaptions. In order to avoid an accident and for ensuring convenience of the subsequent cargo handling heavy subjects should be established on special linings.

The distance from a warehouse wall to a stack has to be equal to 0.6…1.0 m. Sheet steel, channels and high-quality steel are to be put in a stack up to 1.5 m high with linings and laying.

To the works with the hydraulic press only those persons are accepted who have passed the introduction and initial trainings and are aware of the safety methods of the work's performance.

Workers are undergone by the preliminary medical commission after their hiring.

At the beginning on the working process the worker has to put on the safety wear and the individual protection items.

The worker has to check and prepare his working place; to ensure sufficient lighting of his working place.

The hydraulic press must be fixed on the floor surface. Its press corps must not have cracks or any other damages; manometer of the hydraulic press's working pressure must be serviceable; the working zone directed to the side aisles of other equipment must be securely fenced by the protective screen; row materials should not have a tendency to fracture; cylinder should not miss the working fluid.

For the gas welding operation only the persons up to 18 are accepted who passed the medical examination and are trained for the safety methods and technical application to the gas welding.

Each welder must be familiar with the requirements of the general guidelines.

Factory's administration must provide the working process with the relevant working conditions and equipment for the safe working practices.

If the welding works are performed near the electrical wires and cables the latter are to be protected from possible contact.

The working place of the gas welder must be sufficiently illuminated, it is allowed to use 12 v lamp in case of the lack of the light.

Before the works start the working place's conditions and individual protection items are to be investigated.

Gas welding must be operated with the use of the special clothes and the rein made of fireproof material.

For the eyes and face protection special masks are to be applied. Special clothes must be dressed in such a way that there are no hanging or waving edges. The jacket's pockets are to be closed by the valves. The hair should be removed under the hat.

The gas cylinder must be thoroughly inspected: its date of the hydraulic test and its general condition.

The welder must ensure the serviceability of the manometer's hoses, gears, torchers and cutting torchers. He also has to inspect the hoses and the right way of the connection to the gas cylinder, gearboxes and burners.

The welder has to check the availability and serviceability of the fire-fighting equipment. Work in case of their absence is prohibited. Moreover he has to check the availability and serviceability of the ventilation system.

Gas cylinders are to be possessed in places far from the aisles and transport's passage. In case of the vertical installation they are to be fixed.

For the gas cylinders' transportation a cart or a stretcher must be applied. Transportation of the gas cylinders must be provided with screwed caps on them.

Oxygen cylinders are to have blue color with the relevant sign "Oxygen", acetylene cylinders are to have white color with the sign "Acetylene".

It is prohibited to drop or subject to shock any gas cylinders. Besides it is unacceptable to lean against cylinders with wires, electrical lines etc.

Passages between the multistation welding units of the welding must be at least 1.5 m. Passages between the monostation welding units must be at least 1 m. The distance between the fixed welding unit and wall or column should be at least 0.5 m.

SUMMARY

The purpose of the thesis was to make an attempt to develop the safety system on the welding production on an example of Peikko Company and estimate the working conditions on the factory. Different aspects of the working process were considered. Due to the fact that no measurements of indoor microclimate parameters were made and all initial values were taken by the use of the visual estimate and reference materials it can be said that the final results are approximate but quite near to the real ones. In fact real measurements are allowed to be performed only by the specialists in the relevant field.

In accordance with the completed work it can be said that the production process needs to be improved. Some results were unacceptable and implied a threat to the people's life. But in the view of this fact, that this factory has been operating a very short time, even its building is new, it can be said, that now everything is developing on this production quite rapidly.

A great experience was obtained during the thesis writing and wide a range of reference materials, Norms and Standards was studied.

FIGURES

TABLES

EQUATIONS

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- Межотраслевые правила по охране труда на автомобильном транспорте в вопросах и ответах: Пособие для изучения и подготовки к проверке знаний. – М.: Изд-во НЦ ЭНАС, 2004. – 104 с.

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- ТИ Р М-001-2000 Типовая инструкция по охране труда для рабочих, выполняющих погрузочно-разгрузочные и складские работы
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- ГОСТ 12.1.005-88 ССБТю Общие санитарно-гигиенические требования к воздуху рабочей зоны.

- СН № 3223-85, 12.03.85 г., МЗ СССР Санитарные нормы допустимых уровней шума на рабочих местах.

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- СанПиН 2.2.4.548-96, 01.10.96 г., ГКСЭН России Гигиенические требования к микроклимату производственных помещений.

- ГОСТ 12.1.005-88 ССБТ. Общие санитарно-гигиенические требования к воздуху рабочей зоны.

- Р 2.2.013-94, 12.07.94 г., ГКСЭН России Гигиенические критерии оценки условий труда по показателям вредности и опасности факторов производственной среды, тяжести и напряженности трудового процесса.

- ГОСТ 12.1.005-88 ССБТ. Общие санитарно-гигиенические требования к воздуху рабочей зоны.

- ГН 2.2.5.552-96, 21.10.96 г., Предельно допустимые концентрации (ПДК) вредных веществ в воздухе рабочей зоны.

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SAFETY SIGNS
ЗНАКИ БЕЗОПАСНОСТИ
Запрещающие знаки

Запрещается курить

Смысловое значение:	Запрещается курить
Документ:	ГОСТ Р 12.4.026-2001
Обозначение (код):	Р 01
Сигнальный цвет:	Красный
Контрастный цвет:	Белый

Рекомендации по применению:

Использовать, когда курение может стать причиной пожара

Место размещения:

На дверях и стенах помещений, участках, где имеются горючие и легковоспламеняющиеся вещества, или в помещениях, где курить запрещается

Материалы для изготовления знака:

самоклеющаяся пленка, негорючий пластик ПВХ, металл

Рекомендуемые размеры, мм (диаметр круга):

50, 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650

Запрещается пользоваться открытым огнем и курить

Смысловое значение:	Запрещается пользоваться открытым огнем и курить
Документ:	ГОСТ Р 12.4.026-2001
Обозначение (код):	Р 02
Сигнальный цвет:	Красный
Контрастный цвет:	Белый

Рекомендации по применению:

Использовать, когда применение открытого огня и курение может стать причиной пожара

Место размещения:

На входных дверях, стенах помещений, участках, рабочих местах, емкостях, производственной таре

Материалы для изготовления знака:

самоклеющаяся пленка, негорючий пластик ПВХ, металл

Рекомендуемые размеры, мм (диаметр круга):

50, 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650

Проход запрещен

Смысловое значение:	Проход запрещен
Документ:	ГОСТ Р 12.4.026-2001
Обозначение (код):	Р 03
Сигнальный цвет:	Красный
Контрастный цвет:	Белый

Рекомендации по применению:

В местах с опасными зонами

Место размещения:

У входа в опасные зоны, помещения, участки и др

Материалы для изготовления знака:

самоклеющаяся пленка, негорючий пластик ПВХ, металл

Рекомендуемые размеры, мм (диаметр круга):

50, 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650

Запрещается тушить водой

Смысловое значение:	Запрещается тушить водой
Документ:	ГОСТ Р 12.4.026-2001
Обозначение (код):	Р 04
Сигнальный цвет:	Красный
Контрастный цвет:	Белый

Рекомендации по применению:

В местах расположения электрооборудования, складах и других местах, где нельзя применять воду при тушении горения или пожара

Место размещения:

В местах расположения электрооборудования, складах и других местах, где нельзя применять воду при тушении горения или пожара

Материалы для изготовления знака:

самоклеющаяся пленка, негорючий пластик ПВХ, металл

Рекомендуемые размеры, мм (диаметр круга):

50, 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650

Запрещается использовать в качестве питьевой воды

Смысловое значение:	Запрещается использовать в качестве питьевой воды
Документ:	ГОСТ Р 12.4.026-2001
Обозначение (код):	Р 05
Сигнальный цвет:	Красный
Контрастный цвет:	Белый

Рекомендации по применению:

В местах расположения тех водопроводов и емкостей с технической водой, не пригодных для питья

Место размещения:

На техническом водопроводе и емкостях с технической водой, не пригодной для питья и бытовых нужд

Материалы для изготовления знака:

самоклеющаяся пленка, негорючий пластик ПВХ, металл

Рекомендуемые размеры, мм (диаметр круга):

50, 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650

Доступ посторонним запрещен

Смысловое значение:	Доступ посторонним запрещен
Документ:	ГОСТ Р 12.4.026-2001
Обозначение (код):	Р 06
Сигнальный цвет:	Красный
Контрастный цвет:	Белый

Рекомендации по применению:

Для обозначения запрета на вход (проход) в опасные зоны или для обозначения служебного входа (прохода)

Место размещения:

На дверях помещений, у входа на объекты, участки и т.п., для обозначения запрета на вход (проход) в опасные зоны или для обозначения служебного входа (прохода)

Материалы для изготовления знака:

самоклеющаяся пленка, негорючий пластик ПВХ, металл

Рекомендуемые размеры, мм (диаметр круга):

50, 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650

Запрещается движение средств напольного транспорта

Смысловое значение:	Запрещается движение средств напольного транспорта
Документ:	ГОСТ Р 12.4.026-2001
Обозначение (код):	Р 07
Сигнальный цвет:	Красный
Контрастный цвет:	Белый

Рекомендации по применению:

В местах, где запрещается применять средства напольного транспорта (например, погрузчики или напольные транспортеры)

Место размещения:

В местах, где запрещается применять средства напольного транспорта (например, погрузчики или напольные транспортеры)

Материалы для изготовления знака:

самоклеющаяся пленка, негорючий пластик ПВХ, металл

Рекомендуемые размеры, мм (диаметр круга):

50, 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650

Запрещается прикасаться. Опасно

Смысловое значение:	Запрещается прикасаться. Опасно
Документ:	ГОСТ Р 12.4.026-2001
Обозначение (код):	Р 08
Сигнальный цвет:	Красный
Контрастный цвет:	Белый

Рекомендации по применению:

На оборудовании (узлах оборудования), дверцах, щитах или других поверхностях, прикосновение к которым опасно

Место размещения:

На оборудовании (узлах оборудования), дверцах, щитах или других поверхностях, прикосновение к которым опасно

Материалы для изготовления знака:

самоклеющаяся пленка, негорючий пластик ПВХ, металл

Рекомендуемые размеры, мм (диаметр круга):

50, 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650

Запрещается прикасаться. Корпус под напряжением

Смысловое значение:	Запрещается прикасаться. Корпус под напряжением
Документ:	ГОСТ Р 12.4.026-2001
Обозначение (код):	Р 09
Сигнальный цвет:	Красный
Контрастный цвет:	Белый

Рекомендации по применению:

На поверхности корпусов, щитов и т.п., где есть возможность поражения электрическим током

Место размещения:

На поверхности корпусов, щитов и т.п., где есть возможность поражения электрическим током

Материалы для изготовления знака:

самоклеящаяся пленка, негорючий пластик ПВХ, металл

Рекомендуемые размеры, мм (диаметр круга):

50, 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650

Не включать!

Смысловое значение:	Не включать!
Документ:	ГОСТ Р 12.4.026-2001
Обозначение (код):	Р 10
Сигнальный цвет:	Красный
Контрастный цвет:	Белый

Рекомендации по применению:

На пультах управления и включения оборудования или механизмов, при ремонтных и пуско-наладочных работах

Место размещения:

На пультах управления и включения оборудования или механизмов, при ремонтных и пуско-наладочных работах

Материалы для изготовления знака:

самоклеящаяся пленка, негорючий пластик ПВХ, металл

Рекомендуемые размеры, мм (диаметр круга):

50, 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650

ЗНАКИ БЕЗОПАСНОСТИ. ПРЕДУПРЕЖДАЮЩИЕ ЗНАКИ

Предупреждающие знаки

Пожароопасно. Легковоспламеняющиеся вещества

Место размещения и рекомендации по применению: использовать для привлечения внимания к помещениям с легковоспламеняющимися веществами. На входных дверях , дверцах шкафов , емкостях и т . д.

Взрывоопасно

Место размещения и рекомендации по применению: использовать для привлечения внимания к взрывоопасным веществам, а также к помещениям и участкам. На входных дверях, стенах помещения, дверцах шкафов и т. д.

Опасно. Ядовитые вещества

Место размещения и рекомендации по применению: в местах хранения , выделения , производства и применения ядовитых веществ

Опасно. Едкие и коррозионные вещества

Место размещения и рекомендации по применению: в местах хранения , выделения , производства и применения едких и коррозионных веществ

Опасно. Радиоактивные вещества или ионизирующее излучение

Место размещения и рекомендации по применению: радиоактивные вещества или ионизирующее излучение На дверях помещений , дверцах шкафов и в других местах , где находятся и применяются радиоактивные вещества или имеется ионизирующее излучение. Допускается применять знак радиационной опасности по ГОСТ 17925.

ЗНАКИ БЕЗОПАСНОСТИ. ПРЕДПИСЫВАЮЩИЕ ЗНАКИ

Предписывающие знаки

Работать в защитных очках

Место размещения и рекомендации по применению: на рабочих местах и участках , где требуется защита органов зрения

Работать в защитной каске (шлеме)

Место размещения и рекомендации по применению: на рабочих местах и участках , где требуется защита головы

Работать в защитных наушниках

Место размещения и рекомендации по применению: на рабочих местах и участках с повышенным уровнем шума

Работать в средствах индивидуальной защиты органов дыхания

Место размещения и рекомендации по применению: на рабочих местах и участках , где требуется защита органов дыхания

Работать в защитной обуви

Место размещения и рекомендации по применению: на рабочих местах и участках , где необходимо применять средства индивидуальной защиты

ЗНАКИ БЕЗОПАСНОСТИ. ЗНАКИ ПОЖАРНОЙ БЕЗОПАСНОСТИ

Знаки пожарной безопасности

Направляющая стрелка

Место размещения и рекомендации по применению: использовать только вместе с другими знаками пожарной безопасности для указания направления движения к месту нахождения (размещение) средства противопожарной защиты

Направляющая стрелка под углом 45^0

Место размещения и рекомендации по применению: использовать только вместе с другими знаками пожарной безопасности для указания направления движения к месту нахождения (размещение) средства противопожарной защиты

Пожарный кран

Место размещения и рекомендации по применению: в местах нахождения комплекта пожарного крана с пожарным рукавом и стволом

Пожарная лестница

Место размещения и рекомендации по применению: в местах нахождения пожарной лестницы

Огнетушитель

Место размещения и рекомендации по применению: в местах размещения огнетушителя

ЗНАКИ БЕЗОПАСНОСТИ. ЭВАКУАЦИОННЫЕ ЗНАКИ И ЗНАКИ МЕДИЦИНСКОГО И САНИТАРНОГО НАЗНАЧЕНИЯ

Эвакуационные знаки и знаки медицинского и санитарного назначения

Выход здесь (левосторонний)

Место размещения и рекомендации по применению: над дверями (на дверях) эвакуационных выходов, открывающихся с левой стороны. На стенах помещений вместе с направляющей стрелкой для указания направления движения к эвакуационному выходу

Выход здесь (правосторонний)

Место размещения и рекомендации по применению: над дверями (на дверях) эвакуационных выходов, открывающихся с правой стороны. На стенах помещений вместе с направляющей стрелкой для указания направления движения к эвакуационному выходу

Направляющая стрелка

Место размещения и рекомендации по применению: использовать только вместе с другими эвакуационными знаками для указания направления движения

Направляющая стрелка под углом 45°

Место размещения и рекомендации по применению: использовать только вместе с другими эвакуационными знаками для указания направления движения

Направление к эвакуационному выходу направо

Место размещения и рекомендации по применению: на стенах помещений для указания направления движения к эвакуационному выходу

Направление к эвакуационному выходу налево

Место размещения и рекомендации по применению: на стенах помещений для указания направления движения к эвакуационному выходу

ЗНАКИ БЕЗОПАСНОСТИ. УКАЗАТЕЛЬНЫЕ ЗНАКИ

Указательные знаки

Пункт (место) приема пищи

Место размещения и рекомендации по применению: на дверях комнат приема пищи, буфетах, столовых, бытовых помещениях и в других местах, где разрешается прием пищи

Питьевая вода

Место размещения и рекомендации по применению: на дверях бытовых помещений и в местах расположения кранов с водой, пригодной для питья и бытовых нужд (туалеты, душевые, пункты приема пищи и т. д.)

Место курения

Место размещения и рекомендации по применению: используется для обозначения места курения на общественных объектах

РАБОТАТЬ ЗДЕСЬ

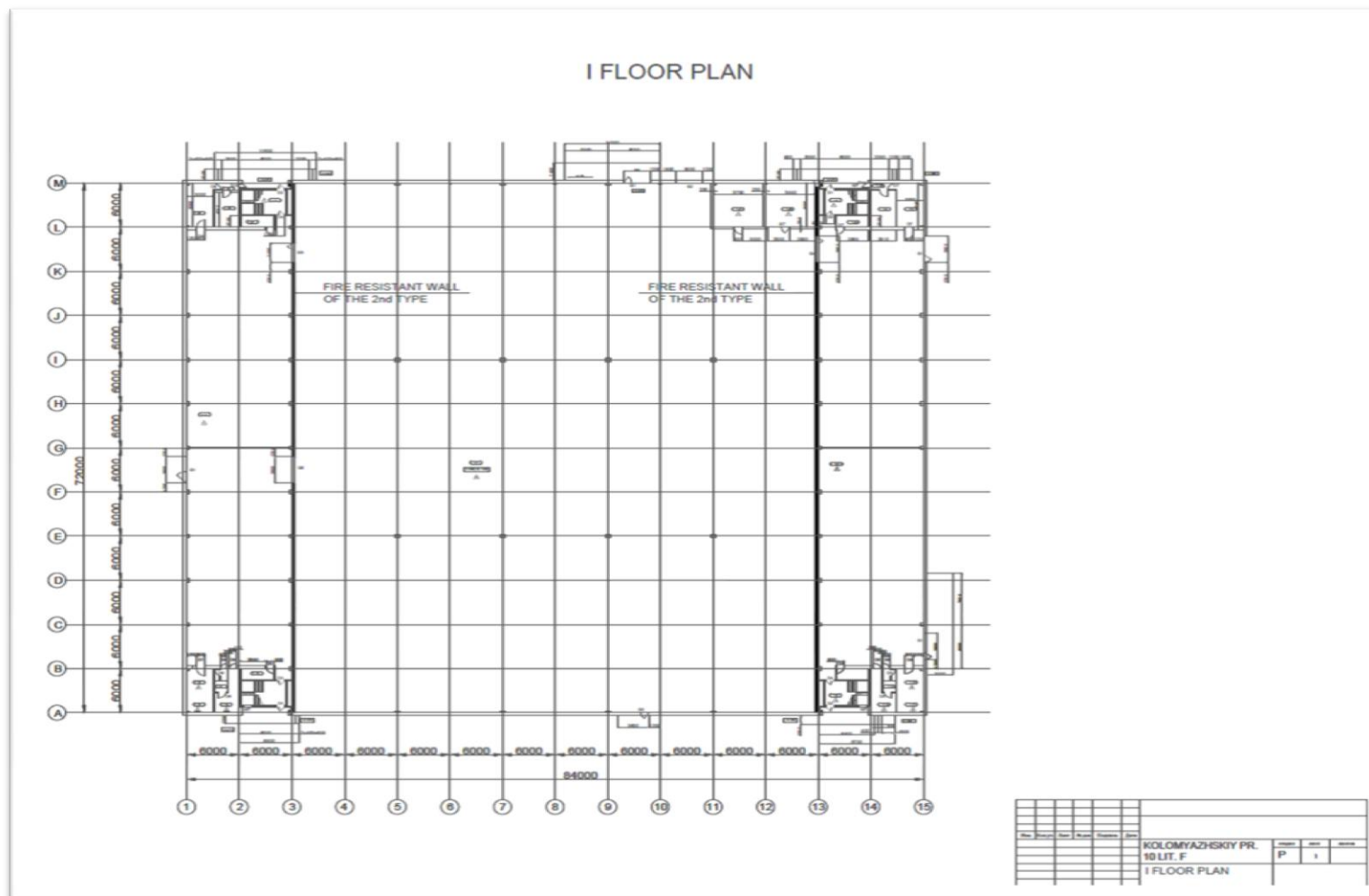Место размещения и рекомендации по применению: для указания рабочего места

ВЛЕЗАТЬ ЗДЕСЬ

Место размещения и рекомендации по применению: для указания безопасного пути подъема к рабочему месту, расположенному на высоте

ЗАЗЕМЛЕНО

I FLOOR PLAN

ПЛАН ЭВАКУАЦИИ

1 ЭТАЖ
СВАРОЧНЫЙ ЦЕХ ООО «ПЕЙККО»

ОПРЕДЕЛИТЕ СВОЕ МЕСТОПОЛОЖЕНИЕ НА ПЛАНЕ
ДЕЙСТВУЙТЕ ПО ИНСТРУКЦИИ

СОГЛАСОВАНО

УТВЕРЖДАЮ

ДЕЙСТВИЯ ПРИ ПОЖАРЕ
СОХРАНЯЙТЕ СПОКОЙСТВИЕ!

СООБЩИТЕ ПО ТЕЛЕФОНУ 01:
- АДРЕС ОБЪЕКТА
- МЕСТО ВОЗНИКНОВЕНИЯ ПОЖАРА
- СВОЮ ФАМИЛИЮ

ОПОВЕСТИТЕ ЛЮДЕЙ
- НАЖМИТЕ КНОПКУ ВКЛЮЧЕНИЯ ПОЖАРНОЙ АВТОМАТИКИ
- ПОДАЙТЕ СИГНАЛ ГОЛОСОМ

ЭВАКУИРУЙТЕ ЛЮДЕЙ
- ОРИЕНТИРУЙТЕСЬ ПО ЗНАКАМ НАПРАВЛЕНИЯ ДВИЖЕНИЯ
- ОКАЖИТЕ ПЕРВУЮ ПОМОЩЬ ПОСТРАДАВШИМ

ПО ВОЗМОЖНОСТИ, ПРИМИТЕ МЕРЫ ПО ТУШЕНИЮ ПОЖАРА
- ИСПОЛЬЗУЙТЕ СРЕДСТВА ПРОТИВОПОЖАРНОЙ ЗАЩИТЫ

ДЕЙСТВИЯ ПРИ АВАРИИ
СОХРАНЯЙТЕ СПОКОЙСТВИЕ!

СООБЩИТЕ ПО ТЕЛЕФОНУ 01:
- АДРЕС ОБЪЕКТА
- ЧТО ПРОИЗОШЛО
- ИМЕЮТСЯ ЛИ ПОСТРАДАВШИЕ
- СВОЮ ФАМИЛИЮ

ЛОКАЛИЗУЙТЕ АВАРИЮ
- ПРЕДОТВРАТИТЕ РАЗВИТИЕ АВАРИИ
- ИСПОЛЬЗУЙТЕ СРЕДСТВА ЗАЩИТЫ

ЭВАКУИРУЙТЕ ЛЮДЕЙ
- ОРИЕНТИРУЙТЕСЬ ПО ЗНАКАМ НАПРАВЛЕНИЯ ДВИЖЕНИЯ
- ОКАЖИТЕ ПЕРВУЮ ПОМОЩЬ ПОСТРАДАВШИМ

ПРИ ПОЖАРЕ ЗВОНИТЬ 01

УСЛОВНЫЕ ОБОЗНАЧЕНИЯ

КНОПКА ВКЛЮЧЕНИЯ ПОЖАРНОЙ АВТОМАТИКИ		НАПРАВЛЕНИЕ ДВИЖЕНИЯ К ЭВАКУАЦИОННОМУ ВЫХОДУ
ОГНЕТУШИТЕЛЬ		НАПРАВЛЕНИЕ ДВИЖЕНИЯ ВВЕРХ/ВНИЗ ПО ЛЕСТНИЦЕ
ПОЖАРНЫЙ КРАН	ВЫХОД	ЭВАКУАЦИОННЫЙ ВЫХОД
ТЕЛЕФОН		ПУТЬ К ОСНОВНОМУ ЭВАКУАЦИОННОМУ ВЫХОДУ
АПТЕЧКА ПЕРВОЙ МЕДИЦИНСКОЙ ПОМОЩИ		ПУТЬ К ЗАПАСНОМУ ЭВАКУАЦИОННОМУ ВЫХОДУ
ЭЛЕКТРОЩИТ		ВЫ НАХОДИТЕСЬ ЗДЕСЬ