Assessment of individual fire risk in public medical institutions with permanent residence of people (on the example of a psychoneurological boarding school)

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Abstract. The process of assessing individual fire risk is considered on the example of a psychoneurological boarding school as a public medical institution with a permanent stay of people. The specifics of the medical institution impose special conditions on the evacuation and rescue of people in case of fire. Conclusions are drawn about the need for additional measures to reduce the risk and supplement the legislative framework.

Keywords: individual fire risk, fire safety, evacuation, psychoneurological boarding school.

Introduction

Recently, due to the development of scientific and technological progress, the use of new technologies and equipment, fires have moved to a new qualitative stage-the time of their development has been reduced, the intensity of fire has increased, the risk of exposure of combustion products to the human body and the environment has increased. Fires began to turn into local environmental disasters, bringing huge spiritual and material losses.

Every year in the Russian Federation there are more than 100 fires in hospital buildings. According to the Federal State Institution VNIIPO of the Ministry of Emergency Situations of Russia, 577 fires in psychoneurological institutions have been registered over the past five years (2015-2020).

Despite all the features of such institutions, general documents on fire safety are applicable for them: the Federal Law "On Fire Safety" (No. 69-FZ of 21.12.1994); Technical Regulations on Fire Safety Requirements (No. 123-FZ of 22.07.2008); codes of rules 486.1311500.2020 " Fire protection systems. The list of buildings, structures, premises and equipment subject to protection by automatic fire extinguishing installations and fire alarm systems. Fire safety requirements"; GOST 12.1.004-91 System of occupational safety Standards (SSBT). Fire safety. General requirements (with Amendment No. 1) and others [1-7].

Purpose of the study – to assess the individual fire risk for people who are being treated and live in public medical institutions of special purpose (neuropsychiatric dispensaries), as well as for the personnel of such institutions.

The system of measures to ensure fire safety in healthcare institutions consists of three main groups:

1. Measures to establish a fire-fighting regime.

2. Measures to determine and maintain the proper fire-fighting condition in all buildings, structures, premises, sites, sites, offices, individual places and points.

3. Measures for the control and supervision of the implementation of fire safety rules during the operation, repair, maintenance of buildings, structures, premises, utility networks, equipment, inventory, etc.

Ensuring fire safety in healthcare institutions can be achieved by implementing all of the above measures. These activities should cover all functional units. These activities should be organized and carried out, first of all, by officials of the institution who, by virtue of their official duties, own, use, operate buildings, structures, premises, plots, offices, equipment, property, inventory, etc., have subordinate personnel who must comply with the requirements of the technical regulations on fire safety. The head of the institution, when distinguishing the responsibilities of subordinate officials, must make sure that each of them fulfills the requirements of fire safety and, in turn, ensures their compliance by subordinate employees in certain areas of work.

To prevent the dangerous effects of fire, to ensure the organized movement of people during evacuation, the removal of material values in buildings, premises, on the floors of buildings, evacuation routes and exits are provided. For each floor and the building as a whole, evacuation plans are made for people and material values. The number of evacuation exits from buildings, premises and from each floor is taken by calculation, but usually there should be at least two of them.

An evacuation plan is being developed, which consists of: graphic and text parts. The evacuation plan is accompanied by a log of working out the evacuation plan (at least 1 time a year, the names and time of working out are entered in the log).

In addition to evacuation plans for the institution as a whole, each room, ward, etc. should be provided with an individual evacuation plan with a reminder of fire safety measures and rules of conduct in fire conditions.

The evacuation plan should show: stairwells, elevators and elevator halls, rooms (rooms) with the designation of doorways, balconies, corridors, external stairs.

In addition to evacuation plans, safety signs are placed in the building of the institution (designation and indication of the locations of fire protection equipment and their elements; desig-

nation of the direction of movement during evacuation, as well as prohibiting, warning, prescriptive and other signs).

Materials and methods

In accordance with the methodology for determining the calculated values of fire risk in buildings, structures and structures of various classes of functional fire hazard, the individual fire risk $Q_в^н$ meets the requirement [3]:

$$Q_в \le Q_в^н , \quad (1)$$

when $Q_в$ – estimated value of individual fire risk, year $^{-1}$; $Q_в^н$ – the normative value of individual fire risk, $Q_в^н = 10^{-6}$ year $^{-1}$.

The calculated value of the individual fire risk for the i-th fire scenario in buildings of the functional fire hazard class F1.1, F1.3, F1.4 is calculated by the formula (2):

$$Q_в = Q_п \cdot (1- (P_э +(1 - P_э) \cdot P_{сп}). \quad (2)$$

The probability of evacuation ($Pэ$) from buildings of the functional fire hazard class F1.1, F1.3, F1.4 is calculated by the formula (3):

$$Pэ = (N_{эв} – N_{н.эв})/ N_{эв} . \quad (3)$$

Results and discussion

Medical institutions are mainly built according to standard projects, the fire resistance of such buildings is in most cases I and II degrees. The development of the fire will occur mainly on the combustible materials. Doors, wooden floors and attic structures are mainly exposed to fire. Since almost all medical institutions have supply and exhaust ventilation, one of the main problems in this situation is the rapid spread of smoke, which makes it difficult to evacuate patients. The main danger is combustion product in X-ray rooms, the release of hydrogen cyanide is possible, in pharmacies and pharmaceutical departments, the release of carbon monoxide and other toxic substances is possible. The presence of flammable substances and objects in pharmacies and laboratories also contributes to the rapid spread of fire. In addition, there are some features in institutions of this type, for example, these are blind bars on the windows and the presence of people who cannot move independently, as well as the possibility of panic. Which is one of the main causes of death of people in fires.

To calculate the individual fire risk, a typical project of a building with dimensions of 68.7×28.8 m, a height of 5.6 m of the II degree of fire resistance was chosen. The walls and partitions are brick, the attic floor is reinforced concrete, the roof is asbestos-cement sheet (slate) according to the wooden crate, there is an attic room, central heating, electric lighting 220 volts. In the external walls there are window openings with dimensions of 2.1×1.7 m, door openings with di-

mensions of 2×1.2 m, in the corridors 2×1.5 m. The building has 1 main and 2 emergency exits. The building can accommodate up to 70 people at the same time. We accept that the fire resistance of the structure, the internal layout, evacuation routes and fire protection systems meet the requirements.

To predict fire hazards, integral (forecast of the average values of the parameters of the environment in the room for any moment of fire development), zone (forecast of the sizes of characteristic spatial zones that occur during a fire in the room and the average values of the parameters of the environment in these zones for any moment of fire development) and field (differential, based on the solution of partial differential equations expressing the fundamental conservation laws at each point of the computational domain) calculation methods are currently used.

In our case, we use a zonal (zone) model. The zone model assumes the allocation of several zones in the room: a smoke layer, a non-smoky layer, a convective column - in which the thermodynamic parameters can be considered homogeneous.

The following assumptions are taken into account in the calculation:

a) the fire is regulated by the load, i.e. the decrease in the amount of oxygen in the fire room is not taken into account;

b) the fire starts at the center of the load and spreads radially at a constant speed.

Suppose that a fire occurs in the physiotherapy room, the initial data for the calculation are presented in Table 1. The results of the calculations of the blocking time for two points are presented in Table 2.

Table 1

Parameter	Unit of measurement	Meaning
Fire area	m^2	1
Typical fuel load	Industrial goods, textiles	
Q - lower heat of combustion	MJ/kg	13,8
v_F - specific mass burnout rate	kg/ (m^2·s)	0,0145
v - linear flame propagation velocity	m/s	0,0045
L_{O_2} - specific oxygen consumption	kg/kg	1,03
D_m - the smoke-forming ability of the burning material	Np·m^2/kg	270
Maximum output CO_2	kg/kg	0,203
Maximum output CO	kg/kg	0,0022
Maximum output HCl	kg/kg	0,014
Fire criteria	Time	
Simulation time	s	400
Initial temperature	°C	20
Number of people in the building	person	70

Table 2

Design point	Blocking time	By increased temperature	By loss of visibility	O_2	CO_2	CO	HCl	By heat flow
No. 01	6,66	6,66	6,66	6,66	6,66	6,66	6,66	6,66
No. 02	0,80	3,28	0,80	4,32	6,66	6,66	1,59	1,59

The estimated time of blocking for the premises of the main stay of people is not dangerous. The blocking time for the calculated point (the location of the fire source) is 48 seconds (0.8 minutes).

The estimated time of evacuation of people t_p from premises and buildings is established by calculating the time of movement of one or more human flows through evacuation passages from the most remote places of accommodation of people. When calculating the entire path of the human flow is divided into sections (passage, corridor, doorway, staircase, vestibule) of length l_i and width δ_i. The initial sections are passages between workplaces, equipment, rows of chairs, etc. When determining the estimated time of evacuation of people, the length and width of each section of the evacuation route for projected buildings are taken according to the project, and for constructed buildings – according to the actual position. The length of the path along the staircases, as well as along the ramps, is measured by the length of the march. The length of the path in the doorway is assumed to be zero. An opening located in a wall with a thickness of more than 0.7 m, as well as a vestibule, should be considered independent sections of the horizontal path having a finite length l_i.

Simulation examples for 4 sites out of 101 are shown in Table 3, floor No.1. The total estimated evacuation time for scenario 1 is 4.893 minutes (or 4 minutes 53 seconds). The accumulation time does not exceed 6 minutes.

Table 3

No. section	Tipe of section	Length, m	Width, m	Number of people	Average horizontal projection people, m^2	Mobility group	Flow density	Evacuation time, min.
1-30	Horizontal path	6,64	3,2	1	0,1	No mobility restrictions	0,005	0,066
30-31	Doorway	0	1,2	-	-	-	-	0,066
13-62	Horizontal path	7,016	4,8	3	0,2	Low mobility group M2	0,018	0,234
62-63	Doorway	0	1,2	-	-	-	-	0,234

The results of determining the calculated values of individual fire risk are summarized in Table 4.

Table 4

Name of the parameter	Parameter value
$Q_{п,i}$ - the frequency of a fire in a building during the year	$1{,}30 \cdot 10^{-2}$

Name of the parameter	Parameter value
$P_{пр,i}$ – the probability of the presence of people in the building	0,0
$P_{э,i}$ – the probability of evacuation of people	0,599
The estimated point at which the worst-case scenario of a fire is observed	1
$t_{бл}$ – the time from the start of the fire to the blocking of evacuation routes as a result of the spread of fire hazards on them at the calculated point, min.	6,667
$t_{н}$ – required evacuation time at the calculated point, min.	5,333
$t_{н.э.}$ – evacuation start time at the calculated point, min.	4,0
$t_{р}$ – estimated time of evacuation of people at the calculated point, min.	4,893
$t_{ск}$ – the time of clusters, min.	0,298
$K_{П.З.,i}$ – the coefficient that takes into account the compliance of fire protection systems with the requirements of regulatory documents on fire safety	0,8704
$K_{ПДЗ,i}$ – the coefficient that takes into account the compliance of the smoke protection system with the requirements of regulatory documents on fire safety	0,8
$K_{СОУЭ,i}$ – the coefficient that takes into account the compliance of the system for notifying people about a fire and managing the evacuation of people with the requirements of regulatory documents on fire safety	0,8
$K_{обн,i}$ – the coefficient that takes into account the compliance of the fire alarm system with the requirements of regulatory documents on fire safety	0,8
$K_{ап,i}$ – the coefficient that takes into account the compliance of automatic fire extinguishing installations with the requirements of regulatory documents on fire safety	0,9
$Q_{В,i}$ – the value of the individual fire risk	$1{,}69 \cdot 10^{-6}$

Conclusion

1. The individual fire risk exceeds the permissible value and is $1{,}69 \cdot 10^{-6}$ year^{-1}, what requires special attention and study.

2. Despite the fact that the fire resistance of the structure, the internal layout, evacuation routes and fire protection systems in the model building of the psychoneurological dispensary meet the requirements of fire safety, people will not have time to evacuate from the building and be exposed to dangerous fire factors. This is due to the fact that the majority of people inside are unhealthy (the M2 mobility group), some of them cannot move independently due to physical or mental abnormalities.

3. In the event of a fire, the main burden and responsibilities for evacuation fall on the service personnel, who must be prepared for actions in emergency situations, fire.

4. We believe that today insufficient attention is paid to the issues of fire safety in such institutions and additional measures (organizational and technical) are needed to improve safety in emergency situations. As well as additional regulatory legal acts containing requirements for such medical institutions.

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