A fire safety control system of educational institutions

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Abstract. The article describes the software system that allows to evaluate the state of fire safety of educational objects. The estimation is based on the analysis of the integral information on all factors influencing a condition of fire safety taking into account specificity of object. The value of fire risk is used as an evaluation indicator. It is calculated in accordance with the methodology approved by the Ministry of Emergency Situations. To facilitate the decision-making process, the system generates a set of recommendations for the decision-maker aimed at improving the level of fire safety of the object of education.

1. Introduction
Russia has one of the highest relative rates of fire deaths in the world. The number of fires per 1000 people is 40% higher than the world average, the number of deaths is 9-10 times higher than the average in other countries. So, for each 100 thousand citizens of Russia there are 10.2 deaths in fires, in the USA, Poland – 1.4, Great Britain – 1.2, Sweden – 0.8, Germany, Austria – 0.7 [1-2]. Such a picture is observed in Russia in all areas of human activity, including at the objects of science and education. At the same time, close attention is paid to ensuring the safety of educational facilities, since such types of facilities are characterized by the presence of a large number of children and adolescents.

Increase of protection of educational objects from fires can be achieved due to automated support of decision-making on the basis of evacuation modeling and development of fires in conditions of current operation of the object. Knowledge of the rules of behavior in case of fire, people at the facility, affect the overall level of fire protection of the object. The necessary level of knowledge for different categories of users can be achieved through virtual training in fire safety and evacuation rules, followed by assessment and control of knowledge [3]. Systematized normative-reference information on fire safety will allow to carry out the check of conformity of the object to the conditions of safe operation in the field of fire safety and to choose the necessary fire-prevention measures. The combination of all these functions in one control system will allow to achieve a qualitative level in support of fire safety at the objects of science and education [4].

The problem of developing decision support systems in fires is being solved in the world. There are many systems providing decision-making support in forest fire management. Firefighting control systems have been developed to eliminate blocking situations when responding to a call. There are systems that analyze buildings for fire safety at the design stage. There are many conferences devoted to the problem of fire safety of objects are held [5-9].
Modern information technologies of fire and evacuation modeling make it possible to provide fire safety management support, identify possible threats of fire and bring the state of fire safety in accordance with regulatory requirements. There are separate programs that allow modeling only people evacuation from the building, or modeling only of propagation of dangerous factors of fire. A decision maker in fire safety management at a facility needs to use several software products, which complicates the risk assessment process and increases the likelihood of errors [4]. The consolidation of mathematical modeling functions, fire risk calculations, intellectual decision-making support, reference and training functions within one system is an actual task.

2. The fire safety control system

Objects of science and education are intended for temporary mass stay of people. The feature of such buildings consists in the variety of functional processes occurring in them, that generates a great variety of geometrical parameters of premises and designs, thus complexity of ensuring fire safety lies in the presence of building blocks with different functional fire hazards. A feature of public buildings is concentration in them of a considerable quantity of people, and as possible presence of people in a dream condition. In this regard, special attention is paid to evacuation issues in such buildings. In buildings with a high concentration of people, the dimensions of evacuation routes and exits is determined in accordance with the standards or special calculations. An important role in the space-planning solution of public buildings is played by communication rooms, the area of which is up to 30% or more of the building area. Communication rooms are intended for organization of entrance and exit, distribution of horizontal and vertical movements of human flows inside the building. Peculiarities of space-planning decisions of objects of science and education in many respects define dynamics of development of fire and distribution of its dangerous factors.

The conditions of current operation of educational facilities lead to changes in the fire load in the premises, to changes in the schedule of operation and the number of people at the same time at the facility, it leads to changes in the estimated value of fire safety, and in some cases requires the adoption of measures to reduce the fire risk. The task of monitoring the state of fire safety of an object is permanent in nature. The person responsible for ensuring fire safety should take into account changing factors in the operation of the facility and make responsible decisions on the management of the facility. A comprehensive assessment of the state of fire safety of the object is a hard task, the solution of which is impossible without the use of specialized software packages. The task of consolidation of functions necessary for estimation of the state of fire safety of the object has been solved within the framework of one system.

The developed information and control system "FS EXPERT" is intended to support managerial decisions on fire safety of educational buildings based on assessment of the current operation of the building, modeling the consequences of fire hazards and evacuation of people from the building. The system is designed for managers, specialists in the field of fire safety management and visitors to educational institutions.

The purpose of the system is to reduce the influence of fire risk-forming factors and increase the level of protection of buildings from fires by providing information support of management based on simulation of evacuation and development of fires, virtual training of fire safety rules and actions in case of occurrence of fire safety threats.

The software package implements a method of consolidation and analysis of the results of modeling the distribution of fire hazard fields and the evacuation process. As a quantitative assessment of the fire hazard of the investigated object in the system the value of fire risk calculated by formulas of methodology of determination of calculated values of fire risk in buildings is used. Functional capabilities of the system are conditionally divided into several blocks. The decision-making unit based on the results of modeling, analysis of the state of the object and assessment of individual fire risk. The unit generate recommendations on the management and support of fire safety of the object. The fire safety measures in terms of feasibility and efficiency is ranked. Based on the knowledge base, support is also provided for the formation of initial data for the analysis of the state of the object.
The modeling unit is a tool for research and analysis of the current operating conditions of the facility in terms of its hazard from the point of view of the threat to human life in case of fire and performs modeling of the spread of fire hazards and evacuation by different methods: field model of fire hazard propagation, field model of evacuation, zonal model of fire hazard propagation and evacuation individual-flow model.

The visualization unit provides 3D representation of the results of modeling the spread of fire hazards and the movement of people, the spread of each of the fire hazards. The data input unit provides the user with the ability to edit databases, describe the characteristics of the object to determine the conditions of safe evacuation, provides the definition of fire and evacuation scenarios. Virtual simulator unit performs the following tasks: checking the compliance of the object with the conditions of safe evacuation; carrying out virtual exercises on evacuation.

To assess the fire safety state of an object it is necessary to enter the initial data into the system: the geometry of the object, using floor plans, arrangement of furniture and the initial position of visitors in the premises of the building, as well as the fire load of the premises. Setting the initial data of the object is performed at the stage of system setup. In the daily operation mode it is possible to correct the initial data. The next step in assessing the condition of the facility is to conduct modeling of two processes: modeling the spread of fire hazards and modeling the evacuation of people from the building. The zonal method for calculating the spread of fire hazards and the individual flow model of evacuation are quite simple and do not require large computational resources. They can be used for rapid assessment of the building condition. For more realistic calculations, it is advisable to use the field method and the individual flow model of people's movement during evacuation.

The simulation the spread of fire hazards without modeling evacuation is possible. For the possibility of a detailed study of this process, the calculation is carried out by the field method with subsequent visualization. To establish the relationship between the movement of people and the process of development of fire hazards, the modeling parameters include event sensors, which, when triggered, affect the change in the spread of the hazard fields (for example, opening doors). The calculation of evacuation using an individual-flow model is performed using the calculated time of blocking the evacuation routes and user-defined parameters.

Consolidation and analysis of modeling results allow to justify measures to reduce fire risk. On the basis of the results of evacuation modeling, the estimated evacuation time and the time of accumulation of people are determined for further calculation of the probability of evacuation and calculation of the fire risk. The analysis of modeling of development of dangerous factors of a fire allows to define time of blocking of evacuation ways which also is used for calculation of fire risk. If necessary, information on user-defined control groups of people and control rooms is determined. The number of people who have been to areas with critical values of hazards is determined, the time of people's presence in the area with critical values of each factor for each person is determined, the total time of people's presence in areas with critical values of fire hazards is determined.

Finding the value of the fire risk is the calculation according to the approved methodology of individual fire risk. The numerical expression of the individual fire risk is the frequency of exposure of a person in the building to hazardous fire factors. The risk is determined for a fire hazardous situation, which is characterized by the greatest danger to life and health of people in the building. Fire risk assessment is carried out by comparing the calculated values of fire risk with the standard value of fire risk. In case of discrepancy between the calculated value of an individual fire risk and the normative value, the process of forming recommendations to increase the level of fire safety is started. The effectiveness of each type of fire prevention measures is determined by the degree of influence on the time of the beginning of evacuation, the time of blocking the evacuation routes and the total time of evacuation. For the fire alarm, smoke protection and evacuation management systems the efficiency is determined by the conditional probability of completing a task in a fire.

As a result of functioning the system allows to reveal a degree of influence of these or those actions on the value of fire risk and thereby evaluate the effectiveness of the recommendations issued to increase the fire safety of the facility, which greatly simplifies the decision-making process.
3. Conclusion
The paper considers the features of educational facilities in terms of ensuring fire safety. The complexity of the task lies in the limited possibilities of experimental research, the need to take into account the specifics of educational facilities and the maximum possible consideration of factors affecting the state of fire safety of facilities.

The management system for decision-making support for fire safety at educational facilities is presented. The system is adequate within the limits of the decision of a task in view of decrease in influence of risk-forming factors and increasing the level of protection of educational facilities from fires due to information support for fire safety management. Support is provided on the basis of evacuation modeling and development of fires in the conditions of current operation of the facility, virtual training in fire safety rules and actions in case of fire safety threats, as well as on the basis of providing advice on measures to eliminate identified violations and compliance of the facility with safe operation conditions.

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