Analytical article
UDC 614.844; DOI: 10.61260/2304-0130-2025-1-74-78

SPECIFICS OF FIRE RISK CALCULATION METHODS APPLICATION

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Abstract. The analysis of modern fire risk assessment methods is carried out in order to develop recommendations for their implementation. The main classes of techniques, their advantages and limitations are considered, as well as recommendations for their adaptation in various operating conditions are given. The main focus is on improving the efficiency in use of these techniques in various industries and situations.

Additionally, the influence of various factors is analyzed, such as the structural features of buildings, the availability of automatic fire extinguishing and smoke extraction systems, as well as organizational measures to ensure fire safety. Special attention is paid to the comparative analysis of deterministic and probabilistic risk assessment methods, as well as the prospects for their integration with modern digital technologies, including machine learning and artificial intelligence systems. Examples of practical application of various techniques in real conditions and their impact on reducing fire risks are considered.

Key words: fire risk, fire safety, assessment, data analysis, prevention, risk management

For citation: Terekhin S.N., Gavrilov D.A. Specifics of fire risk calculation methods application // Supervisory activities and forensic examination in the security system. 2025. № 1. P. 74–78. DOI: 10.61260/2304-0130-2025-1-74-78.

Introduction

Fire risk assessment is a key element in the fire safety system. Modern approaches to risk assessment include a comprehensive hazard analysis, the use of statistical data on fires, as well as physical modeling of fire and evacuation processes. However, despite the development of techniques, their application in practice is often accompanied by difficulties associated with insufficient adaptation to the real conditions and features of the facilities. The purpose of the research presented in the article is to analyze existing approaches and develop recommendations for their effective use.

Federal Law of the Russian Federation № 123-FL dated July 22nd, 2008 «Technical regulations on fire safety requirements» [1] establishes mandatory requirements for ensuring fire safety of facilities and territories. It provides articles concerning the application of methods for determining calculated fire risk values to assess the compliance of facilities with fire safety requirements. The main aspects related to the use of these techniques include the following provisions, presented in table [2].

Table

The main aspects related to the use of fire risk techniques

№ п/п	Main aspects	Statements	Article
1.	Fire risk assessment	Fire risk is defined as the probability of a fire and its consequences, which can lead to threats to human lifes health and property	Art. 6, 19
		To substantiate the safety of facilities, it is allowed to use computational methods for assessing fire risk, which must comply with regulatory documents and approved requirements	
2.	Principles of calculation methods application	Fire risk calculation methods are used to justify deviations from established regulatory requirements or to confirm alternative fire safety measures	Art. 63
		The results of the risk assessment should confirm that the permissible fire hazard level for the facilities has not been exceeded	
3.	Acceptable risk level	The fire risk level is defined as acceptable if the following conditions are met: – the safety of people during evacuation is ensured; – the uncontrolled spread of fire and gorenje products is not allowed; – material losses and environmental damage are minimized	Art. 64
4.	Substantiation of calculations	Fire risk assessment methods should be justified by calculations performed using reliable data on the fire load, the characteristics of the facility and its operating conditions	Art. 65
		Calculations may take into account: – the speed of fire propagation; – the time of evacuation of people; – parameters of fire extinguishing and smoke extraction systems	
5.	Alternative ways to ensure fire safety	Fire risk techniques can be used to justify the use of innovative or non-standard solutions if they provide an equivalent level of safety	Art. 87
		Such decisions must be confirmed by calculations and coordinated with the state supervision authorities	
6.	Responsibility for the validity of calculations	Persons who calculate the fire risk are responsible for the accuracy and validity of the data provided	Art. 70
		Calculations and their results should be stored and provided during inspections	
7.	Development and approval of methodologies	Fire risk assessment methods are developed in accordance with regulatory documents approved by federal executive authorities	Art. 80
		The use of methods is allowed only after their approval and official publication	

Implementation of fire risk assessment methodology

The use of fire risk techniques makes it possible to optimize fire safety measures, take into account the individual characteristics of facilities and effectively manage fire risks without exceeding acceptable threat levels [1, 2].

The existing fire risk assessment methods can be roughly divided into the categories shown in fig. [3].

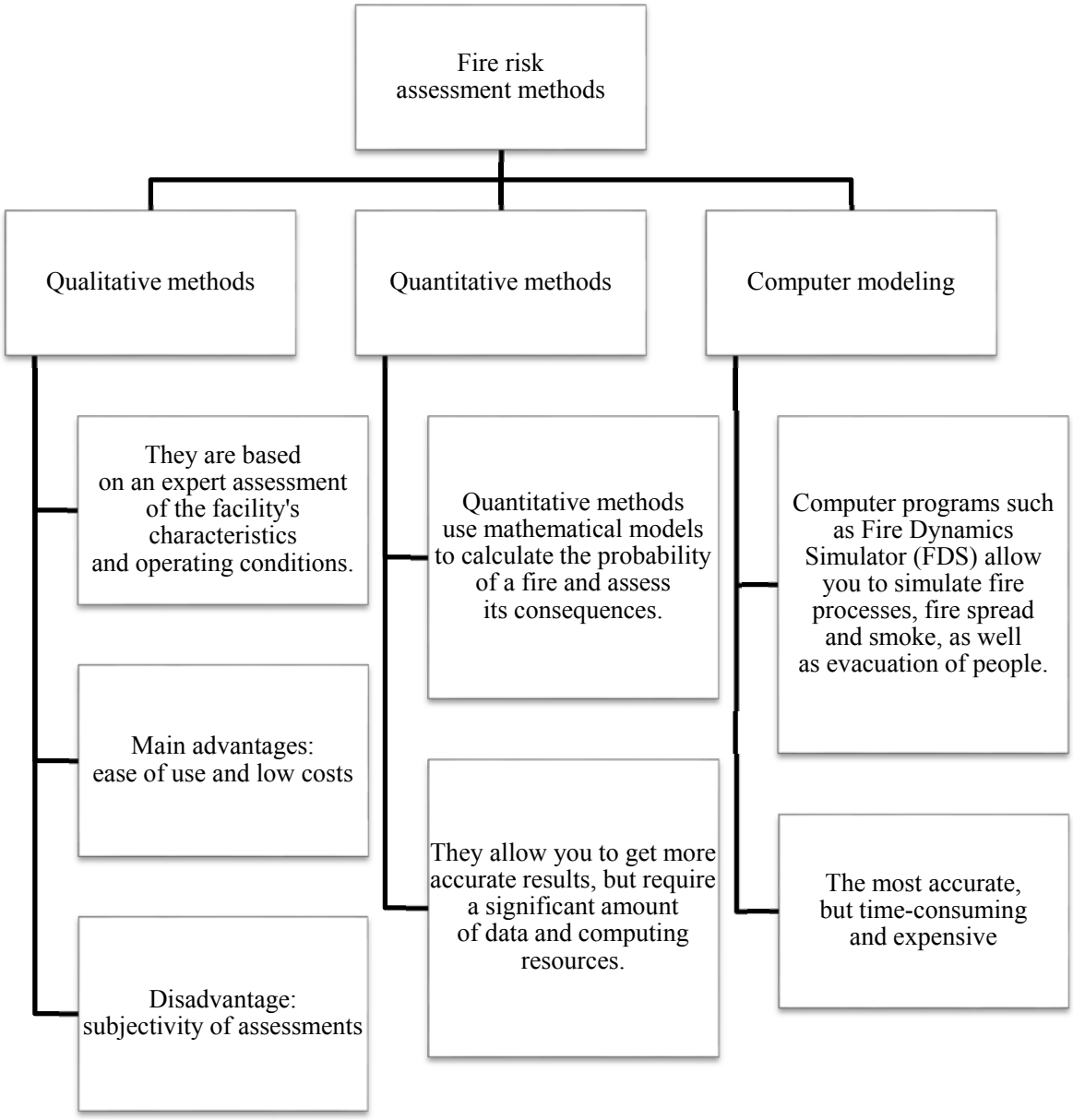

Fig. **Fire risk assessment methods**

Each of the described techniques has its own advantages and limitations, which should be taken into account when choosing an approach for a specific object [4]:

1. Qualitative methods [5].

Qualitative methods are based on an expert assessment of the fire hazard of the facility. These include visual inspection, documentation analysis, and assessment of the facility's compliance with regulatory requirements.

Advantages:

– easy to use: no complex hardware or specialized software is required to perform the assessment.;

– fast execution: allows you to quickly identify the main problems and potential risks;

– versatility: suitable for preliminary analysis of a wide range of objects.

Limitations:

– lack of detail: qualitative methods do not allow for an in-depth analysis of all possible factors affecting fire risk;

– subjectivity: the results strongly depend on the expert's qualifications and personal experience;

– limited applicability: not suitable for complex objects or situations where calculation of risk parameters is required [6].

2. Quantitative methods [7].

Quantitative methods are based on calculations of the probability of a fire, the time of evacuation, the spread of fire and other parameters. Approved formulas and calculation models described in legislation (GOST R 12.3.047–2012 «The system of occupational safety standards. Fire safety of technological processes. General requirements. Control methods») are used.

Advantages:

– high accuracy: Quantitative methods provide detailed results, allowing informed decision-making.;

– regulatory justification: calculations are performed taking into account standards and methods approved at the federal level;

– objectivity: The results are based on mathematical models, not on personal judgments.

Limitations:

– the complexity of the application: performing calculations requires special knowledge in the field of fire safety and working with regulatory documents;

– labor intensity: the calculation process can take considerable time, especially for objects with a high fire load;

– data dependence: the accuracy of the results directly depends on the quality of the source information (for example, the characteristics of building materials and fire load) [6].

3. Computer modeling [8].

Computer simulation is the most modern approach that allows for detailed simulation of fire scenarios. It is based on the use of specialized software such as FDS or Pathfinder.

Advantages:

– high level of detail: The simulation takes into account a variety of factors, including ventilation, smoke propagation, and temperature;

– predictive capability: allows you to evaluate the fire process and its consequences under various scenarios;

– visualization: modeling results are presented in the form of graphs, animations and 3D models, which facilitates the comprehension of information.

Limitations:

– qualification requirements: the use of software products requires highly qualified specialists in the field of fire safety and engineering;

– resource-intensive: modeling requires significant computing power and time;

– high cost: software and specialist services can be expensive, which limits the use of computer modeling for small objects [6].

To make a decision on the choice of an appropriate methodology, the specifics of the facility, the level of fire danger and available resources should be taken into account. For small facilities with a low fire load, a qualitative analysis is often sufficient to identify the key risks. Quantitative methods are optimal for objects of medium complexity, as they allow you to take into account the main parameters without significant costs. For complex objects, such as industrial enterprises, skyscrapers or facilities with a high density of people, it is recommended to use computer modeling, which provides the most complete picture of fire risks [9].

Based on the analysis, the following recommendations are proposed [10]:

– a combined approach. An effective solution is to use a combined approach combining the advantages of different methods. For example, a qualitative assessment can be used for preliminary analysis, while quantitative methods and modeling can be used for detailed study;

– adaptation to the specifics of the object. The methods should be adapted with consideration of specific features of the facility, such as its functional purpose, design characteristics and operating conditions;

– training and professional development. For the successful integration of complex techniques, it is necessary to train staff and provide access to modern software;

– development of national standards. To unify approaches and improve their effectiveness, it is recommended to develop national standards that take into account international best practices.

Conclusion

Thus, each of the techniques has a specific field of application. Their use, depending on the context, allows for the increase of the fire risk management effectiveness and ensurance of people and property safety. Fire risk assessment methodologies are an important safety tool. Their correct choice and adaptation make it possible to reduce the likelihood of fires and minimize their consequences. In the future, the development of methods should be aimed at integrating them with modern technologies, improving the accuracy of calculations and accessibility to a wide range of users.

List of sources

1. Technical regulations on fire safety requirements: Federal law of the Russian Federation dated July 22, 2008 № 123-FZ. Access from the information and legal portal «Garant».

2. On approval of the methodology for determining calculated fire risk values in buildings, structures and fire compartments of various functional fire hazard classes: Order of EMERCOM of Russia dated November 14, 2022. № 1140. Access from the information and legal portal «Garant».

3. Belousov V.A. Fire risk assessment at various facilities: methods and recommendations. Moscow: Safety Technology, 2020. 254 p.

4. The EMERCOM of Russia. URL: https://mchs.gov.ru/ (date of reference: 27.01.2025).

5. Drysdale D., Wiley J. An introduction to fire dynamics, 2011. 545 p.

6. Melnikov A.V. Fire risk assessment: theoretical foundations and practice. M.: Pozhnauka, 2018. 326 p.

7. NFPA. Fire risk assessment methods. URL: https://www.nfpa.org/codes-and-standards (date of reference: 11.01.2025).

8. ISO 16732-1:2012. Fire safety engineering. Fire risk assessment. URL: https://www.iso.org/standard/54789.html (date of reference: 25.01.2025).

9. Ivanov S.P., Kuznetsov I.N. Fire risks: classification, assessment and management. SPb.: Book of science, 2018. 286 p.

10. Semenova L.V., Mikhailov K.P. Analysis of fire risk and development of recommendations for its reduction. N. Novgorod: National Research University, 2021. 307 p.

Information about the article: submitted for editing: 24.02.2025; accepted for publishing: 27.03.2025

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