THEORY AND PRACTICE OF FORENSIC EXAMINATION

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ANALYSIS OF REPORTS ON THE RESULTS OF CALCULATIONS OF FIRE RISKS FOR PROTECTED OBJECTS DURING THE FORENSIC FIRE-TECHNICAL INVESTIGATIONS FOR LARGE RESONANT FIRES DURING CRIMINAL PROCEEDINGS AND THE ARBITRATION PROCESS

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Abstract. The most important aspects affecting the analysis of reports on the results of fire risk calculations performed in the framework of the preparation of special technical specifications and design documentation for warehouse facilities are considered. The analysis was performed during the forensic fire and technical investigations of fires in warehouse buildings, including those with the installed multi-tier mezzanines. The fragments of calculations included in the special technical conditions are studied and provided below. Measures aimed at improving the quality of risk calculations are proposed.

Keywords: fire technical expertise, requirement, fire safety, fire risk

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Introduction

In recent years fires in warehouse buildings and complexes, the damage from which amounts to millions, and in some cases, billions of rubles have occurred in various regions of the Russian Federation. Often storage of goods and products in large warehouse complexes damaged by fire, was envisaged in multi-tier mezzanines. Forensic fire-technical investigations (FTI) for such incidents are carried out in the expert departments of the EMERCOM of Russia (fire testing laboratories), as well as in the fire expertise research center (FERC), which operates as part of the Fire Protection Research Institute of the Saint-Petersburg university of the State fire service of the EMERCOM of Russia.

Investigations in FERC and other expert divisions of the EMERCOM of Russia are carried out on criminal, civil and arbitration cases. The legal principles of forensic investigations are defined by Federal law of May 31, 2001. № 73-FL [1].

As part of the criminal process, investigations are carried out to establish violations of fire safety requirements that existed in the building of the facility during the fire, and the degree of their influence on the resulting consequences is also studied. The material damage and (or) loss of life are considered as the consequences of a fire in warehouse complexes.

During the arbitration case investigation, the presence of violations of fire safety requirements that could have been committed at all stages of a building life cycle – design, construction and (or) operation – is also considered.

However, the main point of interest for the court and all participants of the arbitration process is the assessment of the impact of an individual violation or all violations in a complex on the caused material damage.

Investigations of regulatory specialization in the expert subdivisions of the EMERCOM of Russia are carried out in accordance with the methodological approach set out in paper [2], using algorithms developed and described in papers [3–5].

Main part

Based on the results of research conducted during forensic investigations regarding fires at warehouse complexes, it was established that in most cases special technical conditions (STC) were developed for them in accordance with Art. 78 of the Federal law of July 22, 2028 № 123-FL [6]. At the same time, the provisions of the STC required a calculation to be performed to determine the compliance of the fire risk with the values established by this law.

As part of the fire risk calculations performed, the actual (increased) area of the fire compartment and the peculiarities of the automatic fire suppression system are taken into account (for example, the use of modular powder fire suppression in warehouses with high-rack storage) and other features of the facility.

The range of questions that can be solved by an expert is quite extensive. Below are the main issues considered during the performance of expert investigation on criminal and arbitration cases.

1 group. General questions.

For example, were there any violations of fire safety requirements during the design, construction and operation of the building?

2nd group. Questions that consider the condition of a separate element (installation) of the fire protection system of the facility.

For example, did the automatic fire extinguishing system installed in the warehouse complex building meet fire safety requirements during the incident?

3rd group. Questions concerning the impact of existing inconsistencies in a building on the fire cause, fire spread inside the building or to a neighboring object, as well as on the consequences that occurred.

For example, is there a cause-and-effect relationship between violations (or certain violation) of fire safety requirements and the caused property damage?

To study the first and second groups of questions, the expert requests a large array of necessary materials on the entire life cycle of the object, from design to construction. Sections of the design documentation, positive expert findings, documents on construction supervision, the act of putting the facility into operation, STC, as well as a report are examined according to results of the fire risk calculation, etc.

According to results of fire investigations in warehouse complexes, it is possible to identify fundamental errors made in the fire risk calculating for warehouse buildings. Other errors of an «industrial» nature, which are also allowed in calculating the amount of fire risk for warehouse buildings, are defined in paper [7].

The main errors will be considered using the example of fires, studies of which were carried out at FERC.

First example – a fire in a warehouse complex with a multi-level mezzanine consisting of five fire compartments. At the time of the arrival of the first fire department, the following scenery was observed: thick black smoke belching from the building, open burning on an area of 140x100 m^2, and the threat of spreading to the entire building.

As a result of the fire, the premises in two fire compartments of the building were partially destroyed by fire. The fire area was approximately 55 000 m^2.

For this facility, specific technical specifications were developed and the fire risk was calculated. According to the STC, the tiers (levels) of the mezzanine were allowed not to be equipped with an automatic fire suppression system, provided that certain conditions were met. In this case, it was necessary to take the probability of water fire extinguishing effective operation - equal to zero.

Fragments of STC and fire risk calculation are shown in fig. 1.

FRAGMENT OF STC:

– decisions made should be taken into account when carrying out fire risk calculations, including the peculiarities of the automatic fire suppression system ($C_{AFSS} = 0$)

FRAGMENT OF CALCULATION:

The following fire protection systems are taken into account in the calculations:

Fire alarm system (FAS) (probability of effective performance 0,8)

Fire Warning and Evacuation Management System (FWEMS) in case of fire (probability of effective performance 0,8)

Smoke protection system (SPS) (probability of effective performance 0,8)

Automatic fire suppression system (AFSS) (probability of response 0)

Probability of evacuation through emergency and other exits is assumed as 0,03

Probability of evacuation of occupants in the building upon a fire scenario is the following:

$P_e = 1 – (1– 0,999) *(1– 0,03) = 0,99903$

Probability of effective technical means operation to ensure the safety of people in the building during a fire scenario is the following:

$D = 1 – (1– 0,8) * (1– 0,8) * (1– 0,8) * (1– 0) = 0,992$

Fig. 1. **Fragment of STU and fire risk calculation for a warehouse complex with a multi-tier mezzanine**

In this case, in violation of the requirements of clauses 35, 36 of the order of the EMERCOM of Russia dated July 10, 2009 № 404 [8], the coefficients characterizing the probability of effective operation of technical means required by regulatory documents and the provisions of the STC of the fire alarm system (FAS) and Fire Warning and Evacuation Management System (FWEMS) were incorrectly taken into account.

In accordance with the order of EMERCOM of Russia dated July 10, 2009 № 404 [8], when determining the probability of effective operation of technical means, the use of FAS in combination with FWEMS must be taken into account, that is, the coefficients must be multiplied among themselves.

Second example – a fire in a warehouse building with an installed multi-tier mezzanine.

As a result of the fire, a warehouse building covering an area of 37 000 m^2 and property located in it were destroyed and the glazing of the window openings in a neighboring warehouse building collapsed. By the time the first fire department arrived, the northwestern part of the warehouse building was on fire, popping noises were heard inside the building, about half of the building was engulfed in fire, and thick smoke was belching from the windows and entrances of the second half of the building.

STC developed in 2019 allowed, in the absence of water fire extinguishing, the installation of modular powder fire suppression system, which was subsequently implemented on the object.

Fig. 2 shows a picture of a multi-tier mezzanine, where products for various purposes were stored at different tiers.

Fig. 2. **Warehouse with multi-tier mezzanine**

Fig/ 3 shows a fragment of the STC, from which it follows that the calculation of the fire risk for an object should be carried out without taking into account the effective operation of the fire suppression system and the smoke protection system (due to its absence).

2.4.8. Calculation of the value of individual fire risk for the warehouse area should be carried out without taking into account the probability of effective operation of smoke ventilation and automatic fire extinguishing. When calculating fire risk values, be guided by clause 3 of Article 93 of Federal Law №. 123-FL and take into account the measures provided at the facility for training personnel in actions in case of fire and for social protection of workers, compensating for their work under the higher risk conditions.

Fig. 3. **Fragment of STC developed in 2019 for a warehouse building**

Fig. 4 shows fragments of the fire risk calculation performed within the framework of the STC. In calculating the probability of effective operation of the FAS and FWEMS, they were taken to be unreasonably high (should be equal to 0,8).

Fragment of the calculation:

Thus, in further calculations we will accept the probability of effective systems' response:

– Automatic fire alarm – 0,97

– Fire Warning and Evacuation Management System – 0,97

The calculation of individual fire risk for a scenario.

The estimated frequency of fire occurrence is assumed to be equal to the total frequency of implementation of all possible scenarios of fire occurrence in the building and is equal to $1{,}3\ 10^{-2} = 0{,}013$

Let's calculate the potential risk (we will omit the *j index*)

$P_1 = Q_1\ Q_{d1}$

Q_{d1} – conditional probability of human injury

$Q_{d1} = (1 - P_{Э1})\ (1 - D_1)$

Where:

$D_1 = 0{,}999$ – the probability of effective technical means' response (automatic fire alarm and fire warning and evacuation management systems are provided)

Fig. 4. **Fragment of fire risk calculation for a warehouse building**

In addition, the frequency of fire occurrence was incorrectly assumed in this calculation (fig. 4).

The values of the frequency of fire occurrence per $1m^2$ of object area are contained in papers [8, 9].

This frequency of $1.3x10^{-2}$ was mistakenly taken from the research report [10]. The manual on the application of the methodology contained in the research work [10], was not officially published at the time of the STC writing and the performing of the fire risk calculation, as a result of which it was unlawful to accept frequency data from this document in the calculation under study.

Based on the results of a study of risk calculations for warehouse facilities, the following most common and fundamental errors can also be identified:

– the risk for the facility employee's being at the warehouse enterprise territory is not taken into account;

– underestimated fire frequencies are accepted that do not take into account the specifics of the ongoing technological storage process;

– the total area of all premises in which an emergency situation may occur is not taken into consideration;

– the probability of a person's being in the premises or at the warehouse territory is determined not by the duration of his work shift, but based on the operating time of the facility;

– calculations are not made for residential areas, that is, the danger to people in public and residential areas is not assessed.

In the case under consideration, with the «correct» multiplication of the fire occurrence frequency by the area of the facility, in the absence of a fire suppression and fire protection systems, the magnitude of the fire risk would have been many times greater than a normative meaning.

Conclusion

From the analysis of reports based on the results of fire risk calculations performed within the framework of the STC, as well as on the experience of investigations carried out at the FERC on large and high-profile fires, one should:

1. Fire risk calculations must be carried out by competent personnel who have undergone special training.

2. When considering STCs, special attention should be paid to checking the submitted reports based on the results of fire risk calculations.

3. There is a need to introduce personal liability for those performing such calculations.

Carrying out such calculations confirms the effectiveness of necessary additional measures proposed in the STC, therefore their correct implementation in compliance with all requirements of regulatory legal acts and regulatory documents, ultimately, directly affects the level of fire safety of the facility as a whole.

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